Status, Biology, and Management of Ferruginous Hawks: A Review

by Richard R. Olendorff

U.S. Department of the Interior
Bureau of Land Management
Raptor Research and Technical Assistance Center
3948 Development Avenue
Boise, Idaho 83705

Cover photo: Fledging ferruginous hawk in the Snake River Birds of Prey Area. (Photograph by M. A. Hilliard.)

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A REVIEW

Richard R. Olendorff
Leader, Technical Assistance
Raptor Research and Technical Assistance Center
U.S. Bureau of Land Management
3948 Development Avenue
Boise, Idaho 83705

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Director's Foreword

The ferruginous hawk is an excellent subject for the type of review provided herein by Dr. Olendorff. This large, widely dispersed hawk occurs throughout a large portion of central, western North America, but it has been the object of relatively little research. There has been recent concern that its populations are declining, but the U.S. Fish and Wildlife Service decided not to list the species under the Endangered Species Act of 1973, as amended. This is encouraging because it suggests that the species is not in a long-term population decline, and it avoids the tremendous expenses in money and effort that are required to manage listed species. However, it leaves the responsibility for the conservation of the species to day-to-day research and management, primarily to the U.S. Bureau of Land Management in this country.

Dr. Olendorff's review gives research biologists and resource managers a summary of the literature about ferruginous hawks, a current synopsis of information about population status, and importantly, a discussion and recommendations about management of the species. Now we must take advantage of this convenient, relevant information and work to ensure that the ferruginous hawk does not become threatened or endangered, and that it remains a functional component in the ecosystems of western North America.

Mark R. Fuller, Director
Raptor Research and Technical
Assistance Center
U.S. Department of the Interior
Bureau of Land Management

ACKNOWLEDGMENTS

This paper was first produced by R. R. Olendorff and A. M. Fish in 1985. It was then cited as an unpublished report of the California State Office of the Bureau of Land Management in Sacramento. Between 1985 and 1993 considerably more was published, including a listing proposal by Ure et al. (1991). This necessitated an extensive update and the inclusion of status information to produce the present document.

Several people have assisted in the preparation of this paper. M. N. Kochert of the Raptor Research and Technical Assistance Center (RRTAC) provided extensive comments on the manuscript. Karen Steenhof, also of RRTAC, provided extensive technical review and editing which greatly improved the manuscript. Her efforts are greatly appreciated. The following people provided at least one review: M. J. Bechard, M. W. Call, L.B. Carpenter, M.R. Fuller, R. P. Howard, J. M. Marzluff, J. K. Schmutz, and C. M. White. All of the reviewers have my heartfelt thanks.

Kay Sundberg, RRTAC's Staff Assistant, typed the final copy-ready manuscript. Her talents are excellent and much appreciated.

This paper is dedicated to the memory of Richard E. Fitzner, a personal friend and fellow researcher of the ferruginous hawk and Swainson's hawk. From the late 1960's, when I first met him, until his death in 1992 in an airplane crash doing what he loved most professionally--studying ferruginous hawks--Dick was a positive thinking and doing individual. His calls were refreshingly personal, yet professionally purposeful. He is truly missed by all.

ABSTRACT

The purpose of this paper is to promote the wise management of ferruginous hawk habitat to enable the species to maintain or increase its population levels. Twenty-seven recommendations are presented, supported by reviews of population status, nesting chronology, nest site characteristics, food habits, and spatial considerations. This is followed by discussion of the impacts of human activities on the ferruginous hawk, such as urbanization, cultivation, grazing, land conversion, poisoning and small mammal control, mining, fire and fire management, and other activities.

The ferruginous hawk (*Buteo regalis*) nests in 17 states and 3 provinces of Canada. Many researchers have considered the ferruginous hawk to be declining in numbers. Reasons for these speculated declines include invasion of woodlands into the grasslands, increased cultivation, and overall loss of habitat. Available information indicates that about 5,612 pairs of ferruginous hawks exist according to the U.S. Fish and Wildlife Service, and that the species is neither threatened nor endangered.

Ferruginous hawk nesting chronology in the continental United States is as follows: laying--18 March-13 May; hatching--19 April-13 June; and fledging--30 May-24 July. The average post-fledging period was 27 days. For an individual pair during a single season, a temporal buffer should be at least 99 days from laying to dispersal, provided the laying date is clearly established.

Ferruginous hawks nest in pinyon-juniper (*Pinus* sp.-*Juniperus* sp.), shrublands, and grasslands of the West and rarely nest in dense forest. They use a variety of nesting substrates. The most common nest substrates in 21 studies were trees or large shrubs, followed by cliffs, utility structures, and dirt outcrops. Other nests were found on the ground, haystacks, and buildings. Ferruginous hawks also nest on artificial platforms made for that purpose. This has been a successful management tool.

In 20 studies, ferruginous hawks ate primarily mammals (95.4% by biomass; 83.3% by frequency in a sample of 6,203 prey items). Most common mammals were lagomorphs, ground squirrels, and pocket gophers. Birds constituted only 4% by biomass. The remainder of the diet was comprised of amphibians and reptiles and a trace of insects. Ferruginous hawk productivity is affected by densities of major prey species.

Mean "nearest neighbor" distance between ferruginous hawks on 11 study areas was 3.4 km. Average home range size for 69 birds or pairs of birds during 6 studies was 7.0 km^2.

Impacts of human activities on ferruginous hawks fall into 4 general types: (1) decreased productivity from distrubance: (2) direct mortality; (3) habitat alteration that decreases prey abundance; and (4) habitat alteration that results in loss of nest sites. Low use of cultivated land by nesting ferruginous hawks has been widely reported. In areas where cultivation has increased, ferruginous hawks have decreased. Distribution and improper stocking rates of cattle also affect ferruginous hawks negatively, primarily through adverse effects on prey species. Other types of human disturbance can have similar effects.

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INTRODUCTION

The ferruginous hawk is the largest North American *Buteo* or soaring hawk (Brown and Amadon 1968). It frequently occurs sympatrically with 2 other *Buteos*: red-tailed hawks (*B. jamaicensis*) and Swainson's hawks (*B. swainsoni*) (Schmutz 1977, Cottrell 1981, MacLaren 1986, Restani 1991). Though typical of its genus, it is not particularly close to any other New World *Buteo*. In similar terrain in central Asia the upland buzzard (*B. hemilasius*) is equally large and has very similar habits and ecology (Brown and Amadon 1968). Despite the marked difference in color and pattern, they might be closely related species dating back to the Alaska-Siberia land bridge.

Ferruginous hawks nest in 17 states and 3 provinces of Canada (Olendorff et al. 1989). About 12% of the current breeding range (on the basis of area) occurs in Canada (Schmutz and Schmutz 1980). The breeding range of ferruginous hawks includes the North Dakota to Texas corridor of states westward to Nevada, eastern Oregon, and eastern Washington, and north into the prairie provinces of Canada (Fig. 1). (This map was drawn by the author in 1984 after conferring with the respective state and provincial wildlife personnel.) The species is on the periphery of its range in Washington, California, Arizona, New Mexico, Texas, Oklahoma, Kansas, Nebraska, and Manitoba.

Many authors have considered ferruginous hawks to be declining in numbers (Woffinden 1975; Oakleaf 1976; Powers and Craig 1976; Murphy 1978; Bechard 1981; Evans 1982; Houston and Bechard 1984; Schmutz 1984, 1987b, 1987d, 1991; Schmutz et al. 1984; Bechard et al. 1986; Moore 1987; Smith 1987; Call 1988, 1989; Woffinden and Murphy 1989; Herron 1989, 1990, 1991; Ure et al. 1991).

This decline is exhibited by vacancy at many historical territories, though ferruginous hawks are still common in many parts of their breeding range (e.g., Gilmer and Wiehe 1977, Schmutz 1987b).

Ferruginous hawks winter primarily in the southwestern United States (California to Oklahoma and Texas) and Mexico (Salt 1939, Harmata 1981, Gilmer et al. 1985, Schmutz and Fyfe 1987, Warkentin and James 1988). Low numbers of ferruginous hawks winter in Colorado (Ryder 1969, Johnson and Enderson 1972, Stahlecker and Behlke 1974, Andersen and Rongstad 1989), the Dakotas (Steenhof 1984), Nebraska (Mathisen and Mathisen 1968), and Idaho (Craig 1979). They are nearly absent in winter from Utah (Woffinden 1975, Woffinden and Murphy 1977b).

Ferruginous hawks occur in 2 color phases: a light phase with predominantly white undersides and rufous thighs, and a dark phase appearing black in flight except for the white undersides of the remiges and rectrices (Schmutz and Schmutz 1981; Figs. 2 and 3). Depending on location within the range of the species, about 1 to 10% of ferruginous hawks are dark phased (Weston 1969, Olendorff 1973, Howard 1975, Lokemoen and Duebbert 1976, Schmutz and Schmutz 1981).

STATUS OF THE FERRUGINOUS HAWK

In some states and provinces the status of the ferruginous hawk is little known; in others it is widely known, though there has been a dearth of information for the last 4 to 7 years. A series of new intensive inventories of ferruginous hawk populations is critically needed throughout the species' range for management purposes (LeFranc and Glinski 1988).

This section presents information on the status of nesting ferruginous hawks based on published studies completed since Weston's (1968) study in Utah. Most studies that estimate populations and productivity have been completed during the past 25 years. Before

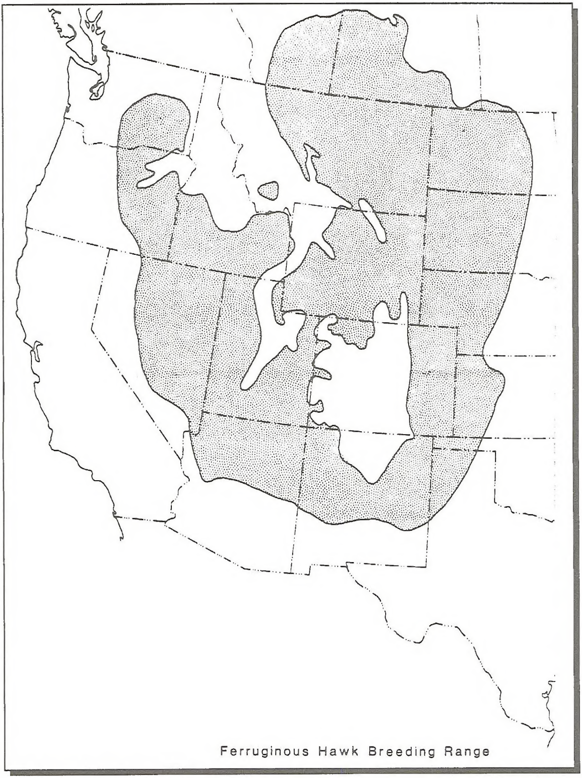

FIGURE 1

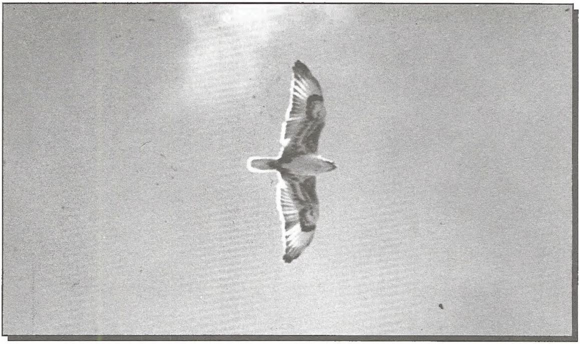

Fig. 2. Light phase ferruginous hawk (the most common). Photograph by R. R. Olendorff.

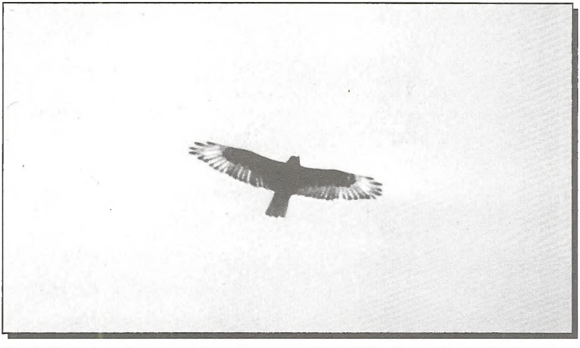

Fig. 3. Dark phase (melanistic) ferruginous hawk (1 to 10% of population). Photograph by J.W. Stoddart, Jr.

then, studies were primarily anecdotal and gave no population figures.

Four parameters were chosen for population comparisons: (1) number of pairs that laid eggs; (2) density expressed as the number of km^2 per laying pair; (3) mean clutch size; and (4) mean number of young per laying pair (Appendix A). A "laying" pair is one that lays at least 1 egg. Although non-laying pairs are recorded in some areas (Ensign 1983; Woffinden and Murphy 1989; K. Steenhof and M. N. Kochert, Bur. Land Manage., pers. commun.), the presence and function of these pairs have not been well studied and remain a subject for more research. "Young per laying pair" is the number of nestlings found in a nest even though age varied. The young were usually old enough to band, but not always the 33-day minimum fledgling age (Steenhof 1987). It was often difficult to determine the age at which banding took place in the studies herein reported. Some studies combine years or give nonstandard parameters on which a consistent analysis cannot be based. I converted data if reported units were not the same as I report here or if further analysis was necessary. Productivity data are "young per laying pair," not "young per successful nesting pair." I report density as 1 laying pair per so many km^2 where it is given. An "attempt" always implies that eggs were laid.

Status Reports by State and Province

Arizona. In Arizona ferruginous hawks are considered an uncommon and irregular breeder and a reasonably common winter visitor (Hall et al. 1988, Olendorff et al. 1989). Although no population estimates exist, the species breeds in 8 areas in the northern part of the state in desert-scrub and grassland habitats. The greatest numbers occur in the drainages of the Little Colorado River and Cataract Creek (Hall et al. 1988). There are probably no more than 5-10 known laying pairs in the state, maybe fewer. Low distribution of laying pairs in Arizona is consistent with patterns of a species on the periphery of its range.

The number of wintering ferruginous hawks in Arizona seems stable or increasing (Hall et al. 1988). They are quite common in northern and southeastern parts of the state, but rare elsewhere.

California. The only recent ferruginous hawk nest in California was reported in the extreme northeast corner of the state in 1987 (Harlow and Bloom 1989). This species winters throughout the state. P. H. Bloom (Western Found. Vert. Zool., pers. commun.) found a winter roost in the Cuyama Valley in 1985 that had up to 24 ferruginous hawks.

Colorado. The earliest extensive work on ferruginous hawks in Colorado was published by Olendorff (1973, 1975) and by Anderson and Craig (1975, 1977). Olendorff (1975) found 26 laying pairs in 2,590 km^2 (1 pair per 99.6 km^2) on the Pawnee National Grassland in extreme northeastern Colorado. Production was 1.9 young per laying pair (1972 only).

In southeastern Colorado in 1973, Anderson and Craig (1975) reported 36 laying pairs on 11,450 km^2 on and near the Comanche National Grassland. Because the entire area was not covered, density was not reported. The 36 pairs produced an average of 1.5 young per attempt. Anderson and Craig (1975) felt that this productivity was low due to 2 spring storms during which winds exceeded 160 km/hr. In 1975, productivity increased to 2.8 young per laying pair (Anderson and Craig 1977), but Anderson (1974) had put up artificial nests and stabilized nests in trees to increase productivity.

In 1977, the Pawnee National Grassland, an area where no management had been done, was compared to the Comanche National Grassland (Craig and Anderson 1979), an area where 26 of 58 nests had been enhanced to

make them less likely to fail (Anderson and Follett 1978). Fifteen laying pairs in the Comanche National Grassland produced 3.1 young per attempt; none failed. On the Pawnee, 29 laying pairs produced an average of 1.6 young per attempt suggesting that humans can significantly improve productivity.

The Pawnee National Grassland was re-surveyed in 1990 (Leslie 1990, 1992), although access was prohibited in the northern Chalk Bluffs portion of the study area where 2 to 4 pairs of ferruginous hawks nested in 1971 and 1972. Nonetheless, Leslie (1990, 1992) found 16 laying pairs with an average productivity of 1.1 young per attempt. This compares to 22 to 24 laying pairs found by Olendorff (1975) for the area studied by Leslie (1990, 1992).

Stalmaster (1988) studied ferruginous hawks nesting in northwestern Colorado and northeastern Utah from 1981 through 1988. The population peaked in 1984 at 30 laying pairs with an average productivity of 1.4 young per attempt. In 8 years of study, 107 of 148 attempts produced an average of 1.9 young per attempt. Because this was a study of a linear railroad right-of-way, it was not appropriate to calculate density. Artificial structures (40 in all) were constructed as the study progressed, thereby making the 148 attempts even less useful in comparing density to areas without artificial structures.

After Stalmaster's first year of study, the population reached a low in 1986 when 11 laying pairs produced 0.8 young per attempt. The decrease from 30 to 11 pairs was attributed to a severe decline in cottontail rabbits (*Sylvilagus* sp.) from 1984 through 1986 (Stalmaster 1988) followed by an increase in both prey and ferruginous hawk nesting success (at least 1 per attempt) in 1987 and 1988 (Appendix A). The study ended in 1988 before the hawks regained their former numbers (30 laying pairs), but the trend was increasing.

Idaho. Ferruginous hawks were studied in southeastern Idaho in 1972 and 1973 by Howard (1975), although his study area included extreme northern Utah as well. Thirty-eight and 27 pairs, respectively, laid eggs on the 2,797-km^2 area, a density of 1 pair per 73.6 and 103.6 km^2, respectively, in the 2 years (Howard 1975, Powers et al. 1975). Productivity was 2.2 and 2.0 young per attempt in the 2 years.

Powers and Craig (1976) studied ferruginous hawks in the Little Lost River Valley in southeastern Idaho in 1972. In their 3,367-km^2 study area they found 11 laying pairs (1 pair per 306.1 km^2) that produced 0.8 young per attempt.

Thurow et al. (1980) compiled data on ferruginous hawks in 988 km^2 of the Raft River Valley in south-central Idaho from 1972 to 1980. They recorded 139 attempts that produced 400 young (2.9 young per attempt per year).

In 1982, as part of his thesis on habitat relationships of *Buteos*, Janes (1985) studied ferruginous hawks near Strevell, Idaho, in the same area as Thurow et al. (1980). He found 13 laying pairs in 273 km^2 (21.0 km^2 per attempt).

The U.S. Bureau of Land Management (unpubl. data) has studied the ferruginous hawk in the Snake River Birds of Prey Area in southwestern Idaho since the mid-1970's. In 7 years between 1976 and 1992 the number of occupied nesting areas increased from 14 (1976) to 24 (1985) and then decreased to 17 in 1992 in the 946-km^2 area for a range of densities of 1 occupied territory per 67.6 km^2 (1976) to 1 per 36.8 km^2 (1985). (Note that these data are based on occupied nesting areas, not laying pairs; thus, they are not included in Appendix A.) Using the proportion of nesting attempts, the number of laying pairs ranged from 13 to 22 during the 7 years. The study

was one of a few that reported non-laying (nonbreeding) pairs. The proportion of non-laying pairs each year ranged from 5 to 40% and averaged 17% (17 of 101 pairs) for all years. A few other studies reported non-laying pairs. In Montana, Ensign (1983) reported 5 non-laying pairs out of 23 (22%) in 1981 and 1982, and Wittenhagen (1992) reported 4 non-laying pairs out of 47 (9%) in Montana in 1991 and 1992. Woffinden and Murphy (1989) also reported a small number of non-laying pairs in Utah.

Bechard et al. (1986) did an extensive nesting survey in southern Idaho in 1985, and stated that distribution of nests had not changed since the early 1970's. In 1985 the ferruginous hawk was "...widely distributed across the southern part of the state," but the population appeared to be less widespread since the time of first settlement (Bechard et al. 1986).

Kansas. Kansas, being on the eastern edge of the ferruginous hawk's range, has only 1 healthy population along the Smoky Hill River in the northwestern part of the state (Roth and Marzluff 1989; J. M. Marzluff, Greenfalk, Boise, Idaho, pers. commun.). Roth and Marzluff (1989) studied this population between 1979 and 1987 and found an average of 1 laying pair per 773.5 km^2 in 31,652 km^2 in any given year. Clutch size averaged 2.9, and the number of young produced was 2.2 young per attempt. This involved an average of about 42 laying pairs per year. They found that accessibility of nest sites to mammalian predators was related to ferruginous hawk productivity--the more inaccessible nests had higher productivity. On average, pairs attempting to nest at inaccessible sites produced 0.8 more nestlings per year. And contrary to expectation, nests adjacent to prairie dog (*Cynomys* sp.) towns were used less often, were less successful, and were successful a lower percentage of years than nests further from prairie dog towns. Failure of nests near prairie dog towns was presumably due to predation on ferruginous hawks by coyotes (*Canis latrans*) seeking prairie dogs.

Up to 14 ferruginous hawks (usually 5 to 10) wintered near prairie dog towns in Finney County, Kansas (Herbert 1987).

Montana. The first extensive study of nesting ferruginous hawks in Montana was in the southeastern part of the state (Ensign 1983). In 1979, 1981, and 1982, he found 13, 12, and 11 occupied territories on 492 km^2 for densities of 1 pair per 37.8, 41.0, and 44.7 km^2, respectively. (All these territories contained pairs, but not all pairs laid eggs. Thus, they are not included in Appendix A.) In 1981 and 1982, birds in 18 occupied territories produced 45 eggs for an average clutch size of 2.5 eggs. Thirty-two eggs hatched, but only 10 young were produced for an average of 0.6 young per occupied territory. Thus, nest failure and hatchling mortality resulted in a very low productivity rate. Frequent abandonment by the male and subsequent fratricide suggests the population was food-stressed, probably due to local drought conditions (Ensign 1983).

In 1985 and 1986, Meyers (1987) found a larger ferruginous hawk population than Ensign (1983) in a 1,080-km^2 study area in southwest Montana. A total of 69 and 58 laying pairs was found for densities of 1 pair per 15.7 and 18.6 km^2, respectively. Meyers assessed productivity for 34 and 38 laying pairs at 1.8 and 1.4 young per attempt.

Harmata (1991) found 23 laying pairs of ferruginous hawks in about 518 km^2 of extreme north-central Montana in 1990, a density of 1 pair per 22.5 km^2.

Wittenhagen (1991, 1992) began a study in southeastern Montana in 1991. In 1991 in 4 small areas totalling 937 km^2 he found 21 laying pairs (1 pair per 44.6 km^2). They laid an average of 3.0 eggs per clutch, and 26 young were produced (1.2 young per attempt;

Wittenhagen 1992). In 1992, 22 laying pairs were found (1 pair per 42.6 km^2) with a clutch size of 3.3 eggs and a productivity of 2.1 young per attempt (Wittenhagen 1992).

Black (1992) found 8 laying pairs in 655 km^2 (1 pair per 81.9 km^2) in Phillips County in north-central Montana.

Nebraska. There are no published papers that give status information on nesting ferruginous hawks for Nebraska, but Call (1979a) estimated 25 laying pairs for the state. The U.S. Fish and Wildlife Service (1992) estimated 35 laying pairs for Nebraska based on the estimate in Ure et al. (1991).

Nevada. Perkins (1982) and Perkins and Lindsey (1983) found 27 laying pairs of ferruginous hawks in the Ely District of the Bureau of Land Management in west-central Nevada in 1981, but reported no density. The 27 laying pairs produced a total of 76 young for an average of 2.8 young per attempt. In 1982, 65 laying pairs were found with a productivity of 2.6 young per attempt. Perkins continued his studies (Herron 1989, 1990, 1991) and found only 31 laying pairs in 1989 (58% decline). The number of laying pairs found in 1990 declined to 27 and increased to 34 in 1991 (48% of the 1982 level). It is possible that 1982 was an abnormally high year and that 27 to 34 pairs is normal.

New Mexico. Hall et al. (1988) reported ferruginous hawks to be more common in New Mexico than in other southwestern states. Seven laying pairs were noted in San Juan and McKinley counties in 1985. During 1986, 10 laying pairs were recorded in the Farmington and Soccoro Resource Areas of the Bureau of Land Management, and 5 laying pairs were reported on the Navajo Indian Reservation. New Mexico Ornithological Society catalogued 22 laying pairs for the entire state between 1966 and 1985 (Hall et al. 1988). Ferruginous hawks winter throughout the state, sometimes commonly (134 in the December 1983 Christmas Bird Count).

J. A. Ramakka, Bur. Land Manage., and R. T. Woyewodzic, Bur. Indian Affairs (pers. commun.) found 26 laying pairs in northwestern New Mexico in 1987 and 1988 which produced 1.9 and 2.0 young per pair. They found between 4 and 12 laying pairs in 1981 to 1986, with productivity averaging between 1.3 and 2.5 young per attempt.

Cully (1988, 1991) reported ferruginous hawks wintering in the Moreno Valley of New Mexico around concentrations of Gunnison's prairie dogs (*Cynomys gunnisoni*). When the prairie dogs died off due to the plague, the ferruginous hawks also declined.

North Dakota. The first systematic work on ferruginous hawks in North Dakota was done by Gilmer and Wiehe (1977). They studied pairs on power line towers that criss-crossed the state and found 21 laying pairs on 1,435 km of power line in 1976, 57% of which were successful. They also found 83% success for 24 laying pairs in non-tower situations that same year.

Gilmer and Stewart (1983) did a more extensive study in North Dakota from 1977 to 1979. On a 16,519-km^2 study area they sampled 629 attempts which resulted in eggs on 26, 5.18-km^2 plots in the Drift Plain, 95 in the Missouri Coteau, and 27 in the Coteau Slope. A complete search was done on 1,259 km^2 of the Missouri Coteau. Densities were 1 laying pair per 16.1 km^2 (78 laying pairs) in 1977, 1 laying pair per 19.7 km^2 (64 laying pairs) in 1978, and 1 laying pair per 13.0 km^2 (97 laying pairs) in 1979. Clutch size for 103 attempts averaged 4.1. Overall productivity was 2.2 young per attempt. Gilmer and Stewart (1983) concluded that the species was reproductively healthy during their study.

In 1983 and 1984, Gaines (1985) resurveyed Gilmer and Stewart's (1983) study area and found 75 (1 laying pair per 16.8 km^2) and 79 laying pairs (1 laying pair per 15.9 km^2), respectively. These densities were similar to those of Gilmer and Stewart (1983). However, nest success (percentage of attempts producing at least 1 young) was lower (62.1%) compared to 1977-1979 (71.1%). Productivity was also lower (1.5 and 1.6 young per attempt) compared to 2.2 in 1977-1979. There were about 2.5 times as many birds nesting on power lines (14 and 16 laying pairs vs. 6 or 7 laying pairs) in 1983 and 1984 than in 1977-1979. Despite these differences, the population was still regarded as reproductively healthy according to Gaines (1985).

__Oklahoma.__ In Oklahoma the ferruginous hawk is considered a rare breeder and uncommon outside the breeding season (Hall et al. 1988). Its current breeding range consists of the Oklahoma Panhandle, with a conservatively estimated 25 laying pairs there (Hall et al. 1988). The wintering population occurs throughout the state, excluding the north-central portion.

__Oregon.__ In 1979 and 1980, Cottrell (1981) found 21 and 26 laying pairs of ferruginous hawks (1 pair per 17.3 and 13.0 km^2, respectively) on 363 km^2 of the Zumwalt Prairie (40 km northwest of Enterprise, Oregon). These birds produced 1.9 and 1.4 young per attempt.

In 1980, Lardy (1980) found 32 laying pairs of ferruginous hawks on 312 km^2 of southeastern Oregon for a density of 1 pair per 9.8 km^2. Clutch size averaged 3.9 (n = 16), and productivity was 3.2 young per attempt. This was in an area of Oregon noted for its high ferruginous hawk population (Lardy 1980).

Janes (1985) studied ferruginous hawks at 3 sites in Oregon. Near Antelope (Rajneesh) in 1978 he found only 1 laying pair in 137 km^2. In 1981 he found 7 laying pairs in 185 km^2 (26.4 km^2 per laying pair) near Boardman, and 13 laying pairs in 449 km^2 (34.5 km^2 per laying pair) near Heppner. In Baker County, Oregon, Woodruff found 33 laying pairs of ferruginous hawks in 1986 (Henjum 1987), with an estimated population of 55 laying pairs in the county.

__South Dakota.__ In 1973 and 1974, Lokemoen and Duebbert (1976) were first to study ferruginous hawks in South Dakota. They studied 269 km^2 of the Missouri Coteau near Long Lake. They found 15 and 12 laying pairs, respectively, for densities of 1 laying pair per 17.9 and 22.4 km^2 in 1973 and 1974. Clutch size for 21 pairs averaged 4.4 eggs. All 27 attempts produced a total of 57 young (2.1 young per attempt).

Blair (1978) and Blair and Schitoskey (1982) studied 7,000 km^2 in extreme northwestern South Dakota in 1976 and 1977. They found 18 laying pairs (1 pair per 389 km^2) in 1976 and 17 laying pairs (1 pair per 412 km^2) in 1977. These densities are low compared to Lokemoen and Duebbert's (1976) study about 323 km to the east. Clutch size averaged 3.3 eggs, and productivity was 2.1 young per attempt.

Steenhof (1984) noted that ferruginous hawks winter in South Dakota (up to 6 at 1 roost).

__Texas.__ Only 7 nesting records for Texas exist (Hall et al. 1988). The most recent ones were in 1966 and 1981 in Dallum County in the Texas panhandle. Schmutz (1987e) reported no known breeders in Texas as of 1987. Ferruginous hawks commonly winter in Texas, being found most often in association with prairie dog towns and cultivated fields (Schmutz 1987e).

__Utah.__ The studies of Howard (1975) and Stalmaster (1988) were discussed earlier for

Idaho and Colorado, respectively. Each study included a small portion of Utah.

Weston (1968, 1969) conducted the first intensive study of ferruginous hawks in north-central Utah. Thirteen pairs laid 20 eggs (1.5 eggs per clutch), and 8 young were produced (0.6 per attempt) in 1967. In 1968 14 pairs laid 50 eggs (3.6 per clutch), and 28 young fledged (2.0 per attempt). Densities were 1 laying pair per 64.8 and 60.1 km^2, respectively, in the 2 years.

From 1967-1970, Smith and Murphy (1973) studied all raptors in 207 km^2 in north-central Utah. In 4 years they found 34 ferruginous hawk nesting attempts that produced 113 eggs (3.3 eggs per clutch) and 68 young (2.0 young per attempt). In an expanded study area (1,170 km^2) in the same locality and the same years, Smith and Murphy (1978) recorded 89 laying attempts of ferruginous hawks (all years combined) with an average clutch of 3.1 eggs and a productivity of 2.0 young per attempt.

Woffinden (1975) and Woffinden and Murphy (1977a, 1989) documented 91 ferruginous hawk laying attempts (all years combined) in 238 km^2 of west-central Utah from 1967-1986. The birds produced 148 young (1.6 young per attempt). The history of this declining population is chronicled in Appendix A. Woffinden's and Murphy's (1989) results show that a ferruginous hawk population does not always rebound after its prey population (primarily jackrabbits [*Lepus* sp.]) crashes, even though the prey population rebounds.

Janes (1985) found 17 laying pairs of ferruginous hawks in 274 km^2 (16.1 km^2 per laying pair) near Vernon.

Washington. Beery (1974) did the first systematic survey of ferruginous hawks in the 12 counties of southeastern Washington. He found 9 nests with eggs; only 3 produced young (0.6 per attempt). In 1975, in that part of the state, Fitzner et al. (1977) found 12 laying pairs with 2.5 young per attempt.

A remnant juniper forest just east of Hanford Atomic Energy Reservation contained 75 attempts by ferruginous hawks in 12 years between 1975 and 1991. They were not studied intensively to get clutch size or productivity, except in 1987-1990 (L. D. Jurs, Bur. Land Manage., pers. commun.). During those 4 years, 26 attempts produced a total of 44 young (1.7 young per attempt).

Wyoming. The first population studies of ferruginous hawks in Wyoming occurred in 1978 and 1979 (Wadell and Yde 1979, Oakleaf 1985). Game and Fish biologists found 24 laying pairs with a density of 1 pair per 151.0 km^2, but they admitted that their surveys were only 50% complete (Oakleaf 1985). Wadell and Yde (1979) studied in 2 areas of the Rawlins District of the Bureau of Land Management. In one area they found 8 laying pairs with a density of 1 laying pair per 46 km^2. On the other area they found 5 laying pairs in 616 km^2 (1 laying pair per 123.2 km^2).

Platt (1986) surveyed 254 km^2 of the Rock Springs District, Wyoming, between 1979 and 1985. He found between 5 and 15 pairs laying eggs each year for a total of 70 attempts. They produced 115 young (1.6 young per attempt).

In 1981 and 1982, MacLaren (1986) found 17 and 13 laying pairs (1 pair per 41.9 and 55.0 km^2), respectively, in 712 km^2 of southeastern Wyoming. They produced 2.5 young per attempt.

Several people have studied ferruginous hawks around Shamrock Hills in the Rock Springs District of the Bureau of Land Management (Farrell 1987; Call 1988, 1989; Tigner 1989a, 1989b; and Call and Tigner 1991). This population has benefitted

significantly from artificial nest structures. Between fall 1988 and fall 1991, 65 structures were placed in the area for a total of 206 opportunities over 4 years (26 in 1988, 54 in 1989, 61 in 1990, and 65 in 1991). Ferruginous hawks laid eggs at 119 of these 206 opportunities (105 successful) and produced an average of 2.3 young per attempt. At the same time, ferruginous hawks laying in natural nests decreased in Shamrock Hills from 31 in 1987, to 8 in 1988, to 16 in 1989, to 6 in 1990, to 4 in 1991, suggesting that some pairs in the population shifted to the artificial structures. Hawks using artificial structures were also more successful than those using natural nest sites (2.3 vs. 1.4 young per attempt).

Phillips and Beske (1990) mapped 119 laying pairs of ferruginous hawks on their 14,554-km^2 study area in northeast Wyoming between 1981 and 1989. Apparently, this was a composite of all pairs that nested between 1981 and 1989, and thus not usable for density determination. Ferruginous hawks were the most abundant species in the area, except for the golden eagle (*Aquila chrysaetos*).

Alberta. The most work on ferruginous hawks has been done in Alberta, primarily by Schmutz and his associates (Schmutz 1977, 1983, 1984, 1987a, 1987b, 1987c, 1987d, 1989a, 1989b, 1991; Schmutz and Fyfe 1987; Schmutz and Hungle 1989; Schmutz and Schmutz 1980, 1981; Schmutz et al. 1980, 1984, 1988; Fyfe and Armbruster 1977; Moore 1987). Fyfe and Armbruster (1977) experimented with management techniques, but provided little data on population status of ferruginous hawks. In 1975 and 1976, Schmutz (1977) found 26 and 24 laying pairs, respectively, in his southeastern Alberta study area which was 335 km^2 in 1975 (1 pair per 13.0 km^2) and 480 km^2 in 1976 (1 pair per 20.0 km^2).

In 1982, Schmutz (1984) estimated the population of ferruginous hawks in 74,686 km^2 of southeastern Alberta (virtually the entire breeding range in Alberta) by sampling 80, 41-km^2 randomly selected quadrats. He estimated 1,082 pairs (1 pair per 69.0 km^2). (Note: It is difficult to report laying pairs in this case because only a small portion of the nests were actually found.) In 1987, Schmutz (1987b) resurveyed this area and estimated that 1,791 pairs of ferruginous hawks nested (1 pair per 41.8 km^2), about 700 more pairs than in 1982. This increase was statistically significant, more so in grassland than in cultivated land. The increase was due primarily to an increase in the ground squirrel population and secondarily to increased use of artificial nest structures (2.6% of the total nesting population used artificial structures in 1987). This study was redone in 1992 with an estimate of 1,702 pairs, indicating a fairly stable population which decreased only about 5% (Schmutz 1993). A similar study will be done every 5 years until the species is no longer threatened in Canada (J. E. Schmutz, Univ. Saskatchewan, pers. commun.).

Moore (1987) and Schmutz (1987b) stated that in the mid-1980's ferruginous hawks occupied only 60% of their former range in Alberta due to expansion of aspen (*Populus tremuloides*) park land in the northern part of the range and cultivation throughout.

Manitoba. In 1984, Ratcliffe and Murray (1984) documented the first known nesting of the ferruginous hawk in Manitoba in 57 years. In 1985, 3 laying pairs were noted, and they produced 4 young. In 1987 and 1988, 11 and 32 laying pairs, respectively, were found, and Manitoba's population was estimated at 40 to 50 pairs (De Smet and Conrad 1991). The hawks seem to be adapting to a different situation than elsewhere within their range as is indicated by: (1) greater use of nests high in trees; (2) greater success in these high nests compared to lower nests; (3) greater than expected use of, and success in, extensively cultivated areas; (4) nesting by many pairs near roads or within small but dense aspen groves;

(5) greater than expected use of aspen; and (6) extensive feeding on northern pocket gophers (*Thomomys talpoides*) (De Smet and Conrad 1991).

Saskatchewan. Houston and Bechard (1984) reported a decline of ferruginous hawks in Saskatchewan from the turn of the century to the early 1980's, but gave only anecdotal historical figures on which to base the decline. They stated that in Saskatchewan 40% of the hawk's original range was no longer occupied by nesting hawks, another 40% was severely depleted due to cultivation, and 20% was still occupied but at a reduced density. They estimated that in 1984 the population was perhaps 10% of its original level.

Houston (1985, 1991), however, noted that ferruginous hawks were doing well in small pockets of available habitat. This was most evident on the 63.5-km^2 Kindersley-Elna Pasture where 130 attempts occurred in 18 years up to 1988 with a production of 365 young (3.2 young per attempt).

Smith (1987) estimated the current range of the species in Saskatchewan to be 150,000 km^2. This represents a decrease of about 220,000 km^2 since 1920 due to growth of trees in aspen park land in the northern part of the ferruginous hawk's range. The population of the entire province was estimated at 170 pairs (Smith 1987). Smith (1987) reported only young per successful nest, so his data are not presented in Appendix A. These data, however, show a slight decline in productivity from 1974 through the mid-1980's.

Banasch (1991) surveyed about 3.4% of the current ferruginous hawk range in Saskatchewan from 1988-1990. Although her data are not convertible to the Appendix A format used here because she gave young per successful nest, she concluded that numbers of pairs were slightly higher than indicated by Houston and Bechard (1984).

Estimates of the Entire Population

Call (1979a) estimated the minimum numbers of ferruginous hawks in 17 states, Saskatchewan, and Alberta at between 2,810 and 3,590 nesting pairs (5,620 to 7,180 individuals) as of 1979 (Table 1).

New information indicates that the population was higher in the early 1990's. Harlow and Bloom (1988) reported 1 pair in California (Table 1). Hall et al. (1988) increased the estimate for Oklahoma to 25 pairs. J. M. Ramakka, Bur. Land Manage., and R. T. Woyewodzic, Bur. Indian Affairs (pers. commun.) made a minimal estimate for the population of New Mexico. They set it at 26 pairs, though their data was from the northwestern part of the state only. Lardy (1980) revised his estimate given to Call (1979a) for Oregon to 250 pairs. Oakleaf (in Call 1985) revised his estimate for Wyoming to >800 pairs. The estimate for Alberta was increased as a result of Schmutz's (1993) work. Saskatchewan's population estimate was refined by Smith (1987), and Manitoba's population was estimated by De Smet and Conrad (1991; Table 1).

These new figures revised the population estimate in the United States and Canada for the early 1990's to between 2,921 and 5,665 nesting pairs (5,842 to 11,330 individuals; Table 1). Call (1985, 1988) further analyzed his 1979 calculations of minimal numbers of ferruginous hawks and estimated the 1985 and 1988 population in the United States and Canada at between 5,000 and 7,500 nesting pairs. From Appendix A, it is clear that ornithologists have studied only about 120 nesting pairs per year for the past 16 years (only 50 nesting pairs per year for the 9 years before that). Furthermore, populations have not been monitored consistently. Assuming a population of 5,000-7,500 laying pairs (Call 1985), between 1-2% of the naturally occurring population has been

Table 1. Estimated number of nesting pairs of ferruginous hawks in the United States and Canada.[a]

State/Province	Source (from Call 1979a)[b]	1979 Estimates	1992 Estimates
Arizona	Luckett, Russo	5 - 10	5 - 10
California	Schlorff	0	1 [c]
Colorado	Craig, Anderson	150 - 175	150 - 175
Idaho	Howard, Powers, Bammann	200 - 250	200 - 250
Kansas	Roth, Rolfs	25 - 50	25 - 50
Montana	Sadowski, Shryer, Bricco	175 - 250	175 - 250
Nebraska	Lock	25	25 [a]
Nevada	Herron	250 - 300	250 - 300
New Mexico	Hubbard, Buoy	10	26 [c]
North Dakota	Gilmer	350 - 400	350 - 400
Oklahoma	Smith	10 - 20	25 [c]
Oregon	Kindschy, Sheter, Kniesel	125 - 150	250 [c]
South Dakota	Lokemoen, Duebbert	350 - 375	350 - 375
Texas	Brownlee	5 - 10	5 - 10
Utah	Murphy, Wagner, Call	200 - 225	200 - 225
Washington	Fitzner	30 - 40	30 - 40
Wyoming	Oakleaf, Call	400 - 600	> 800 [c]
Alberta	Fyfe	350 - 400	1,181 - 2,223 [c]
Saskatchewan	Fyfe	150 - 200	170 [c]
Manitoba			50 [c]
Total Estimated No. Nesting Pairs		2,810 - 3,590	2,921 - 5,665

[a] 1979 column adapted from Call (1979a); 1992 increases derived from figures in the text.
[b] Call gave names, not citations.
[c] New 1992 estimates documented in text.

monitored--a small proportion of the total number of ferruginous hawks.

In their petition to list the ferruginous hawk under the Endangered Species Act, Ure et al. (1991) estimated the population at 6,836 birds in the United States, 2,000 in Canada, and about 10% (884) floaters--or the equivalent of 4,860 pairs. This value is consistent with other estimates of the entire population and is even exceeded by the U.S. Fish and Wildlife Service's response to the petition (U.S. Fish and Wildl. Serv. 1992).

The response to the petition estimated 5,220 to 6,004 (mean 5,612) pairs of ferruginous hawks and concluded that "the petition presented information insufficient to conclude that the required action may be warranted" (U.S. Fish and Wildl. Serv. 1992). A suggested increase of nearly 2,400 pairs came from a comparison of Call's (1979a) values and those derived by the U.S. Fish and Wildlife Service (1992). Call's (1979a) mimeographed paper was never meant to be a final estimate; it was the best information available at the time and was reconsidered to be 5,000 to 7,500 in 1985 and 1988 (Call 1985, 1988).

Schmutz (1987d) estimated North America's population based on his observations of hawks banded in Alberta and seen in Texas. His estimate of 14,000 individuals (7,000 pairs) for North America was realistic based on an estimate of 3,000 individuals in Alberta and parts of North Dakota combined. His wintering estimates suffer from small sample size (2 banded adult birds out of 49 trapped in Texas from an estimated banded live population of 581 adult birds).

Population figures suggest that Bechard et al.'s (1986) statement is still true today: "...further research is necessary before listing them as threatened or endangered species can be justified." A well-designed and consistent inventory and monitoring effort is necessary if a true picture of ferruginous hawk numbers is to be gained.

Reasons for Speculated Ferruginous Hawk Declines

The best documentation of declining numbers of ferruginous hawks can be found in large-scale declines in southern Saskatchewan (Houston and Bechard 1984, Smith 1987), Alberta (Schmutz and Schmutz 1980; Schmutz 1984, 1987b, 1987c, 1989b; Moore 1987), and Manitoba (Bechard 1981, De Smet and Conrad 1991) due to invasion of aspens into the prairie and increased cultivation. The discoveries of more ferruginous hawk nests in southwestern Manitoba after a 57-year absence (Ratcliffe and Murray 1984, De Smet and Conrad 1991) is encouraging. This is not considered a significant recovery toward historical numbers which will probably never occur again because historical conditions no longer exist. Stewart (1975) documented the near extirpation of ferruginous hawks from the northeastern quarter of North Dakota. Woffinden and Murphy (1989) chronicled the decrease of a population in Utah.

Declines apparently are occurring in many parts of the species' range (Evans 1980, 1982), but they have been confirmed only in northern Utah and eastern Nevada in the past 5 to 7 years (Woffinden and Murphy 1989; G. B. Herron, Nev. Dep. Wildl., pers. commun.). These declines are due, at least in part, to the relative absence of a secondary prey species (Woffinden and Murphy 1989). Ferruginous hawks exist on jackrabbits in these areas, and ground squirrels (*Spermophilus* sp.) and prairie dogs are either non-existent or reduced in numbers (Woffinden and Murphy 1989).

Woffinden and Murphy (1989) offered a second partial explanation for the extirpation of ferruginous hawks in their northern Utah study area. When prey got so low, remaining hawks became nomadic and searched out more favorable areas to nest. Although it is difficult to prove conclusively, "nomadism" may explain why ferruginous hawk populations make such dramatic population fluctuations. This was proposed as a cause of the tremendous increase in the 1987 population of ferruginous hawk in Alberta (Schmutz 1987b). Similarly, it could be responsible for increases of 50% or more in populations studied by Gilmer and Stewart (1983), Woffinden and Murphy (1989), Jurs (U.S. Bur. Land Manage., pers. commun.), and Platt (1986; Appendix A).

A well-known reason for declines in other raptor populations, pesticides, does not appear to be related to any decline of ferruginous hawk numbers. Stendell et al. (1988) assessed organochlorine and mercury levels in ferruginous hawk eggs collected from 1974 to 1978 in North and South Dakota and concluded that residues were below levels known to adversely affect reproduction.

LIFE HISTORY INFORMATION IMPORTANT TO MANAGEMENT

Nesting Chronology

Laying, hatching, and fledging dates for birds vary annually depending on local and regional weather conditions and food availability in nesting habitat (Welty 1962:158). Although most studies of ferruginous hawks have been 1 to 3 years in duration (insufficient to record the full range of egg laying, hatching, and fledging dates), the following generalities apply to most ferruginous hawks in the continental United States between 38 degrees and 49 degrees North Latitude: egg laying--18 March - 12 May; hatching--19 April - 13 June; and fledging--30 May - 24 July (Weston 1968, Olendorff 1973, Howard 1975, Schmutz 1977, Blair 1978, Smith and Murphy 1978, Cottrell 1981, Gilmer and Stewart 1983, U.S. Bur. Land Manage. unpubl.).

Only in Alberta (51 degrees 25' N) (Schmutz et al. 1980) and Saskatchewan (M. J. Bechard, Boise State Univ., pers. commun.) is there a noticeable difference in these dates. Laying begins at this latitude 2 to 3 weeks later than has been recorded for any United States population. Fledging in Alberta occurred only a few days later than has been recorded for late pairs in southern Idaho (42 degrees N) (Howard 1975, Powers 1981) and northeastern Colorado (41 degrees N) (Olendorff 1973). In central Utah (40 degrees N), fledging rarely occurred after the first week of July (Weston 1968, 1969; Smith and Murphy 1973; Woffinden 1975; Woffinden and Murphy 1983b).

For an individual nesting pair of ferruginous hawks during a single season, one can establish a laying date by aging nestlings and then subtracting 31 days for incubation (Smith and Murphy 1978). An aging key from 7 to 40 days of age is provided by Moritsch (1985). To estimate a safe date for human entry into the nesting area for land treatments or other developments, add 41 days for brood-rearing (Steenhof 1987) and an average of 27 days for dispersal (Blair 1978, Harmata 1981, Ensign 1983, Woffinden and Murphy 1983b). This represents a total of 99 days from laying and 68 days from hatching. Konrad and Gilmer (1986) added another 18 days to the post-fledgling period, allowing the young 45 days for dispersal. This is consistent with their finding that young were only 1.6 km away from their nest 28 days after fledging. These are general rules; dates should be refined as the nesting season progresses to be more precise.

Nest Site Characteristics

Ferruginous hawks occur in western forests (pinyon-juniper forests), shrubs, grasslands, shrubs and grasslands, and near water (Table 2). Of particular importance is the pinyon-juniper/shrub steppe ecotone which provides trees for nesting adjacent to open foraging areas (Powers et al. 1975, Thurow et al. 1980). Dense forests are relatively unimportant as ferruginous hawk habitat (Smith and Murphy 1973), except for scattered pinyon-juniper forests. Sparse riparian forests, the periphery of forests (Smith and Murphy 1973, Woffinden 1975), terrain features such as cliffs and rock outcrops (Roth and Marzluff 1989), and isolated trees and small groves (Lokemoen and Duebbert 1976, Cottrell 1981) add greatly to habitat diversity and thus suitability for ferruginous hawks. Trees planted by unsuccessful homesteaders and farmers in

Table 2. Potential natural vegetation types (Kuchler 1964) for major ferruginous hawk study areas in the United States. Percentages are estimated to the nearest 5% from visual inspection of study areas plotted on Kuchler's (1964) map. Potential natural vegetation types are as described and aggregated in Kuchler (1964). In this case, western forest is all pinyon juniper.

		Potential Natural Vegetation Types				
Reference	State	Western Forest	Shrub	Grassland	Shrub and Grassland	Water
Olendorff (1973, 1975) Leslie (1992)	CO			100%		
Andersen & Rongstad (1989)	CO	70%		30%		
Thurow et al. (1980) White & Thurow (1985)	ID	25%	25%		50%	
U.S.B.L.M. (Unpubl. Data)	ID				100%	
Howard (1975) Powers (1981)	ID/UT	10%	10%		80%	
Roth & Marzluff (1989)	KS			100%		
Ensign (1983)	MT			100%		
Restani (1991)	MT			100%		
Gilmer & Wiehe (1977) Gilmer & Stewart (1983) Gaines (1975)	ND	5%		95%		
Lardy (1980)	OR		15%		85%	
Cottrell (1981)	OR			100%		
Lokemoen & Duebbert (1976)	SD			100%		
Blair (1978)	SD	5%		95%		
Weston (1968, 1969) Woffinden (1975) Smith & Murphy (1978) Woffinden & Murphy (1989)	UT	20%	30%		40%	10%
MacLaren (1986)	WY				100%	
Platt (1986)	WY				100%	
Call & Tigner (1991)	WY		20%		80%	

otherwise unbroken grasslands (Olendorff 1975, Maser et al. 1979b, Yoakum et al. 1980) are especially important. Each broad classification of ferruginous hawk habitats can be subdivided by plant communities, terrain features, and watersheds. Weston (1968, 1969) and Woffinden and Murphy (1983a) noted that ferruginous hawks nesting in pinyon-juniper habitats showed a clumped distribution in isolated nest trees and on rock outcrops on the slopes peripheral to the valley floor. Likewise, Cottrell (1981) found that ferruginous hawks did not utilize habitat types in proportion to their occurrence in the wheatgrass-blue grass (*Agropyron* sp.-*Poa* sp.) areas of northeastern Oregon. She found heavy use of south-facing rock outcroppings, lone pines (*Pinus* sp.) on north exposures, and aspen groves, and little or no use of scablands, pine groves, and cultivated land. Yet, ferruginous hawks still used 6 of 9 available habitat types.

Olendorff and Stoddart (1974) divided their shortgrass prairie study area into unbroken grasslands, creek bottoms, cliffs, and cultivated lands. Ferruginous hawks were the most versatile of the larger raptors and nested in all 4 habitat types, though only 1 of 71 nests occurred in cultivated land which was plowed annually. Of the large raptors, only the red-tailed hawk--a true "generalist"--is considered more versatile in its use of habitat types (Cottrell 1981, Knight and Smith 1982), but very few red-tailed hawks occurred in the northeastern Colorado study area (Olendorff 1973).

Several researchers have studied nesting resource partitioning among the 3 congeneric *Buteo*s: ferruginous hawks, Swainson's hawks, and red-tailed hawks (Schmutz 1977, Schmutz et al. 1980, Cottrell 1981, Janes 1985, MacLaren 1986, Bechard et al. 1990, Restani 1991). In Montana (Restani 1991) and in Washington (Bechard et al. 1990) ferruginous hawks and Swainson's hawks nested at about the same height above ground (4.0 m--Montana; 8.7 m--Washington), with red-tailed hawks nesting about twice as high (8.9 m--Montana; 17.6 m--Washington). Schmutz et al. (1980) found about the same relationships in Alberta. Differences in nest height between the 3 areas most likely was between the trees present rather than a difference in the hawks. In Wyoming, red-tailed hawks also nested about twice as high as ferruginous hawks (4.6 m for ferruginous hawks; 7.2 m for red-tailed hawks; MacLaren 1986).

Ferruginous hawks nested at a lower elevation than either of the other 2 *Buteo* species in Montana (Restani 1991), Washington (Bechard et al. 1990), and Wyoming (MacLaren 1986). Differences were small, and elevations were characteristic of the surrounding terrain (for ferruginous hawks 2,075 m in Montana; 275 m in Washington, and 2098 m in Wyoming). Apparently, elevation is not an important characteristic for ferruginous hawk nests except that it must be less than 2100 m.

Ferruginous hawks used a variety of nest substrates in 22 studies throughout western North America (Table 3). Figures in Table 3 represent the total number of nesting attempts reported for each study, and data may be biased because a nest may be counted more than once if it was used in subsequent years. Data were not weighted for number of years studied, number of nests in each study, or study location. Table 3 also excludes studies where artificial structures designed specifically for raptors were used. The most common nest substrates used by ferruginous hawks in these studies (2,119 nests; Table 3) were trees or large shrubs (49%) followed by cliffs (21%), utility structures (12%), and dirt outcrops (10%). Other nests were found on the ground (6%), haystacks (2%), and buildings (0.1%; Fig. 4).

Table 3. Nest substrates used by ferruginous hawks in 21 study areas throughout western North America. Each nest was counted multiple times if it was used in multiple years.

Reference	Study Years	State	Cliff	Tree/ Shrub	Dirt Outcrop	Ground	Utility Structure[a]	Building	Haystacks	Totals
Knight & Smith 1982	1978-79	WA	8 (100%)							8
Bechard et al. 1990	1975-80	WA	18 (62%)	10 (34%)			1 (4%)			29
Fitzner et al. 1977	1974-75	WA	5 (24%)	16 (76%)						21
Lardy 1980	1979-80	OR	12 (39%)		6 (19%)	12 (39%)	1 (3%)			31
Cottrell 1981	1979-80	OR	29 (62%)	17 (36%)		1 (2%)				47
White & Thurow 1985	1978-80	ID	100 (93%)	3 (3%)	3 (3%)	1 (1%)				107
Howard 1975	1972-73	ID/UT	93 (96%)		3 (3%)	1 (1%)				97
Bechard et al. 1986	1985	ID	34 (89%)		2 (5%)	2 (5%)				38
U.S.B.L.M. (unpubl. data)	1976-92	ID	181 (58%)	11 (4%)	1 (0%)	19 (6%)	102 (32%)			314
Roth & Marzluff 1989	1979-87	KS	130 (72%)	17 (9%)	28 (16%)	6 (3%)				181
Smith & Murphy 1982	1967-71	UT	3 (3%)	53 (59%)	22 (25%)	12 (13%)				90
Perkins & Lindsey 1983	1981	NV		92 (100%)						92
Lockhart et al. 1980, pers. commun.	1979	WY	1 (8%)	1 (8%)	10 (84%)					12
MacLaren 1986	1981-82	WY	7 (30%)	5 (22%)	10 (43%)		1 (5%)			23
Olendorff 1973, Olendorff & Stoddart 1974	1970-74	CO	8 (11%)	49 (69%)	8 (11%)	4 (6%)		2(3%)		71
Restani 1991	1987-88	MT		20 (83%)		3 (13%)	1 (4%)			24
Gilmer & Stewart 1983	1976-79	ND		361 (58%)	66 (11%)	35 (6%)	113 (18%)		44 (7%)	619
Lokemoen & Duebbert 1976	1973-74	SD		13 (48%)		12 (44%)			2 (8%)	27
Gaines 1985	1983-84	SD		107 (69%)		7 (5%)	30 (19%)		10 (7%)	154
Blair 1978	1976-77	SD	21 (55%)		12 (32%)	3 (8%)			2 (5%)	38
Schmutz 1984	1982	ALTA		36 (77%)		10 (21%)	1 (2%)			47
De Smet & Conrad 1991	1984-88	MAN	49 (100%)							49
Totals			438 (21%)	1036 (49%)	199 (9%)	131 (6%)	254 (12%)	3(0%)	58(3%)	2119

[a] Windmills are included as utility structures.

Fig. 4. Ferruginous hawk nest atop an abondoned house chimney on the Pawnee National Grassland in northeast Colorado. Photograph by R.R. Olendorff.

Adaptability of ferruginous hawks in their use of nesting substrates (the actual physical supports for their nests) has resulted in inadvertent benefits to the species from the settlement and development of the West since the late 1800's (Olendorff 1973). Human situations that these hawks have used for nesting include abandoned farmsteads where settlers planted many non-native trees prior to the droughts of the 1920's and 1930's (Olendorff 1973, Olendorff and Stoddart 1974, Maser et al. 1979b, Yoakum et al. 1980, Gaines 1985, Schmutz 1989b). Electrical transmission towers and power poles now provide elevated nesting substrates for ferruginous hawks throughout the West (Howard 1975, Call 1976, Lokemoen and Duebbert 1976, Gilmer and Wiehe 1977, Lardy 1980, Thurow et al. 1980, Gilmer and Stewart 1983, White and Thurow 1985, Steenhof et al. 1993). Haystacks adjacent to both native and cultivated hay fields have sometimes been used as nesting substrates in the Dakotas (Rolfe 1896, Davy 1930, Lokemoen and Duebbert 1976, Gilmer and Stewart 1983, Gaines 1985).

Gaines (1985) found 44.8% of ferruginous hawk nests to be in human-made situations such as those mentioned above; 53.5% of the nestlings were produced from such sites. Similarly, Olendorff and Stoddart (1974) found 40.8% of the ferruginous hawks nesting in human-created situations in their northeastern Colorado study area; 44.4% of 57 nestlings were from these nests.

Howard and Hilliard (1980) tested the effectiveness of artificial nest platforms with

shade structures for ferruginous hawks. In late 1975, 12 pairs of platforms were installed in areas in and near the Snake River Birds of Prey Area in Idaho. Each pair of structures consisted of 1 with a sun shade and 1 without, about 137 m from each other. Thus, 12 opportunities to nest on artificial platforms were available from 1976-1979 (48 platform-years). Seven nesting attempts by ferruginous hawks occurred during that time (15% occupancy), 5 of which were successful. No ferruginous hawks nested on the shaded structures.

In 218 platform-years of availability between 1982 and 1988 on his Colorado/Utah study area, Stalmaster (1988) found 46 (20.4% of platform years) ferruginous hawk attempts. Collectively, the 46 attempts produced 1.0 young per nest, compared to 1.5 young per nest for all other nest attempts on his study area.

In Saskatchewan, Houston (1982) made 60 platform-years available to ferruginous hawks between 1973 and 1982. Eleven nesting attempts occurred during that period, an occupancy rate of about 18%.

In Alberta, during autumn 1975, 98 artificial platforms and nesting baskets were installed (Schmutz et al. 1984). Between 1981-1983, 18 of these structures were lost. Occupancy of the 80 remaining structures by laying pairs averaged about 14% per year. Many important benefits of artificial structures were also documented. Ferruginous hawk nesting density in the study area increased by 56% (from 9 to 14 pairs), a significantly higher rate of increase than in a control area where no artificial structures were present. The increase was not a result of redistribution of nesting pairs from adjacent areas. Within 2 years after installation up to 40% of the pairs in the study nested on platforms; however, during the next 6 years, up to 79% of the pairs used platforms. Pairs nesting on artificial structures also fledged more young than those nesting on the ground or in trees in the study area, and shaded nests were occupied statistically more often than unshaded nests as suggested by Olendorff (1973) in Colorado, but not corroborated by Howard and Hilliard (1980) in Idaho.

Another successful artificial structure program was reported by Call and Tigner (1991). From 1988 to 1991 on their study area in the Shamrock Hills of Wyoming there were 206 platform-years available. Eggs were laid in 119 (57.8%) attempts which resulted in 269 young (2.3 young per attempt). This compared to 1.4 young per attempt from 65 attempts at natural nests from 1987 to 1991.

Steenhof et al. (1993) reported on a transmission line in Idaho and Oregon with artificial structures used as mitigation. Fifty-two nesting attempts by ferruginous hawks occurred on towers along the line between 1983 and 1989, about half on artificial platforms placed on towers and half in other tower positions. Nesting success on the platforms did not differ from that on other parts of the tower. The nesting attempts produced 2.3 young per pair over the 7 years of the study. Pairs nesting on transmission line towers had significantly greater success than pairs nesting on natural substrates, but similar to other power lines.

Food Habits

In 20 studies (Table 4, Appendix B), ferruginous hawks ate primarily mammals (95.4% by biomass; 83.3% by frequency in a sample of 6,203 prey items) . Cottontail rabbits, jackrabbits, ground squirrels, prairie dogs, pocket gophers (*Thomomys* sp.), and kangaroo rats (*Dipodomys* sp.) were particularly important in the diets studied. Although fledgling passerines and other birds were taken during late spring and early summer to feed nestling hawks (Olendorff 1973, Blair and Schitoskey 1982, Ensign 1983), birds constituted only 4.1% by biomass (13.2% by frequency) of the overall diet. The remainder of the diets was comprised of 0.5% amphibians

Table 4. Prey of ferruginous hawks by major animal groups (derived from Appendix B). Figures for "Mammals" are in parentheses because they are subcategorized immediately below. "tr." means less than 0.05% (i.e., "trace").

Prey Items	*n*	Frequency %	Biomass %
Mammals	(5,166)	(83.3)	(95.4)
Bats	1	tr.	tr.
Lagomorphs--Hares and Rabbits	1,228	19.8	65.9
Rodents--Marmots	1	tr.	0.3
Rodents--Squirrels and Prairie Dogs	2,719	43.8	25.4
Rodents--Pocket Gophers	492	7.9	2.6
Rodents--Pocket Mice	47	0.8	tr.
Rodents--Kangaroo Rats	412	6.6	0.7
Rodents--Cricetine Mice and Rats	135	2.2	0.1
Rodents--Microtine Mice and Rats	83	1.3	0.1
Rodents--Old World Mice	8	0.1	tr.
Unidentified Rodents	3	tr.	tr.
Carnivores	15	0.2	0.1
Unidentified Mammals	22	0.4	0.2
Birds	822	13.2	4.1
Amphibians and Reptiles	147	2.4	0.5
Insects	68	1.1	tr.
GRAND TOTALS	6,203	100.0	100.0

References for prey items: Weston (1969), Olendorff (1973), Howard (1975), Lokemoen and Duebbert (1976), Fitzner (1977), Blair (1978), Smith and Murphy (1978), Schmutz et al. (1980), Thurow et al. (1980), Cottrell (1981), Powers (1981), Ensign (1983), Gilmer and Stewart (1983), Roth and Marzluff (1984), Steenhof and Kochert (1985), MacLaren (1986), Stalmaster (1988), Andersen and Rongstad (1989), Harmata (1991), Restani (1991). The number of prey items on which this table is based is shown in Table 5.

and reptiles by biomass (2.4% by frequency) and a trace of insects (1.1% by frequency).

Of mammals, rabbits and hares made up 65.9% by biomass, but ground squirrels and prairie dogs were taken most frequently (Table 4). In 12 of 20 study areas ground squirrels and prairie dogs were the prey taken most often (Table 5). Only in south-central Idaho, north-central Utah, and southeastern Montana were rabbits and hares taken most often. Pocket gophers were the most common prey (based on

Table 5. Relative importance (1 [most important], 2, or 3) of rabbits and hares (JR), ground squirrels and prairie dogs (GS), and pocket gophers (PG) as prey of ferruginous hawks on 20 study areas for which more than 40 prey items were recorded. Based on frequency.

Study	State (# Prey Items)	Prey Item		
		JR	GS	PG
Fitzner et al. (1977)	Washington (161)	3	2	1
Cottrell (1981)	Oregon (82)	- [a]	1	2
Steenhof and Kochert (1985)	Idaho (221)	3 [c]	2 [c]	1 [c]
Powers (1981)	Idaho/Utah (46)	2	1	- [a]
Howard (1975)	Idaho/Utah (197)	2	3	1
Thurow et al. (1980)	Idaho (112)	1	3	2
Weston (1969)	Utah (283)	1	2	- [a]
Smith and Murphy (1978)	Utah (957)	1	2	- [a]
Olendorff (1973)	Colorado (131)	2	1	3
Andersen and Rongstad (1989)	Colorado (43)	3	2	1
Stalmaster (1988)	Colorado/Utah (476)	2	1	- [a]
Ensign (1983)	Montana (504)	1 [b]	2 [b]	3 [b]
Restani (1991)	Montana (190)	3	1	2
Harmata (1991)	Montana (75)	2	1	3
Gilmer and Stewart (1983)	North Dakota (449)	3	1	2
Lokemoen and Duebbert (1976)	South Dakota (129)	3	1	2
Blair (1978)	South Dakota (683)	2	1	3
Roth and Marzluff (1984)	Kansas (72)	2	1	3
MacLaren (1986)	Wyoming (278)	2	1	3
Schmutz et al. (1980)	Alberta (1,115)	2	1	- [a]

[a] Not found on study area.
[b] PG more important in low prey years and overall; GS more important in low prey years.
[c] Low GS years: PG, GS, JR; high GS years: GS, PG, JR.

frequency) in Washington, southwestern Idaho in low prey years, and in south-central Colorado (Table 5).

Ferruginous hawks may shift to other prey when their principal prey species declines (Steenhof and Kochert 1985). In some areas, however, there is no alternate prey when the primary species crashes, and hawk numbers decrease in these situations (Woffinden and Murphy 1989). For example, in southeastern Idaho (Howard 1975, Thurow et al. 1980) and northern Utah (Woffinden and Murphy 1989) there are few ground squirrels and prairie dogs for ferruginous hawks when jackrabbit populations decline. In Wyoming, where jackrabbit and cottontail populations were low for a number of years, ferruginous hawks existed on ground squirrels (Call 1988).

The overlap in the diets of sympatric *Buteo*s is extremely high. In Wyoming, ferruginous hawks had a diverse diet, showing greatest overlap with red-tailed hawks (96.0-98.6%; MacLaren 1986). (All dietary overlaps mentioned in this paragraph are based on frequency.) Steenhof and Kochert (1985) found an overlap of 73% between red-tailed and ferruginous hawks in Idaho. Schmutz et al. (1980) found that the diets of ferruginous hawks and Swainson's hawks in Alberta overlapped by 98% (1975) and 82% (1976). Ferruginous hawk and Swainson's hawk diets in Oregon overlapped by 83% in 1979 and 95% in 1980 (Cottrell 1981). In Wyoming, Restani (1991) found the greatest dietary overlap between red-tailed and ferruginous hawks (98%), intermediate between red-tailed and Swainson's hawks (93%), and least between ferruginous hawks and Swainson's hawks (86%).

Importance of Major Prey Items

Ferruginous hawk productivity is affected by the densities of major prey (Stalmaster 1988, Schmutz and Hungle 1989, Woffinden and Murphy 1989). In areas of Idaho and Utah that supported jackrabbit populations, studies by Woffinden (1975), Woffinden and Murphy (1977b, 1989), Smith and Murphy (1978, 1979), Thurow et al. (1980), Smith et al. (1981), and White and Thurow (1985) suggested a correlation between jackrabbit numbers and the number of ferruginous hawks laying eggs, eggs laid, and young produced. This occurred where jackrabbits were 95% of the ferruginous hawk diet. Both the number of nesting attempts and the clutch size appear to be lower during low jackrabbit years (Thurow et al. 1980).

Similar relationships between ferruginous hawks and ground squirrels have been reported in response to ground squirrel population fluctuations (Steenhof and Kochert [1985] in Idaho; Lardy [1980] in Oregon; Schmutz [1987b], Schmutz and Hungle [1989], and Schmutz [1991] in Alberta). Schmutz (1987b) reported that ferruginous hawks would be scarce in Alberta if it were not for ground squirrels. Breeding density and fledging success of ferruginous hawks were consistently correlated with ground squirrel abundance in Alberta (Schmutz and Hungle 1989). Nesting chronology seems to be keyed to the emergence of young ground squirrels and the fledging of birds. Ferruginous hawks in Alberta hatch about the time young ground squirrels emerge (Schmutz 1989b). Olendorff (1973) observed that young ferruginous hawks in Colorado hatch at the same time horned larks (*Eremophila alpestris*) and western meadowlarks (*Sturnella neglecta*) fledge.

In winter, ferruginous hawks occur more commonly around cultivated fields containing numerous northern pocket gophers (Schmutz 1987e) or around prairie dog towns (Herbert 1987, Schmutz and Fyfe 1987, Cully 1988). On the wintering grounds in Texas ferruginous hawks occur in areas of greater than 95% cultivation (Schmutz 1987e). More research is needed to determine the suitability of cultivated land as wintering habitat (LeFranc and Glinski

1988). Ferruginous hawks seem to avoid cultivation more in summer than in winter (Schmutz 1987e).

Spatial Considerations

Data on use of space by ferruginous hawks are useful to a land manager in judging quality of existing and potential habitat for the species. For example, managers must know if a ferruginous hawk can reproduce on 5 km^2 or if it needs 40 or 100 km^2. How far away from other ferruginous hawks will a pair make a new nest? Knowing this, space use considerations may also help in developing strategies and goals for habitat improvements to maintain or enhance ferruginous hawk populations.

During 22 study years on 11 study areas mean "nearest neighbor" distance between ferruginous hawk nests was 3.4 km (range: 0.8-7.2 km; Table 6). In Alberta, each *Buteo* species "...maintained a minimum distance between its nests but often nested closer to other species..."--even when the opportunity to nest farther away was available (Schmutz et al. 1980: 1084). Association of ferruginous hawks with congeners was corroborated by Thurow and White (1983) and Bechard et al. (1990). Ferruginous and Swainson's hawks nest close to each other for the benefit derived from mutual defense of their overlapping home ranges (Thurow and White 1983). This association apparently is beneficial down to a minimum spacing of *Buteo* nests of 0.3 km (Schmutz et al. 1980) and to a point where 1 nest is directly visible from another (Cottrell 1981).

Home range sizes for ferruginous hawks were determined in 69 cases (either a single bird or a pair of birds around 1 nest) during 6 studies (Table 7). Average home range size for all 69 birds or pairs of birds was 7.0 km^2.

IMPACTS OF HUMAN ACTIVITIES

Impacts of human activities on ferruginous hawks fall into 4 general types: (1) increased human disturbance that results in decreased productivity; (2) direct mortality; (3) habitat alteration that decreases prey abundance; and (4) habitat alteration that decreases nest site availability. Of particular interest to land-use planners are 5 activities that represent ultimate causes of ferruginous hawk population decline: urbanization, cultivation, grazing, land conversion, and poisoning (Olendorff et al. 1989).

Studies indicate that nesting ferruginous hawks avoid human disturbance. Blair (1978) found that the mean distance from 36 nests to human activity was significantly greater than from 36 randomly selected points in South Dakota (means = 3.31 and 2.47 km, respectively). Similarly, in South Dakota, Lokemoen and Duebbert (1976) found 11 of 12 ferruginous hawk ground nests farther from human disturbance than the mean distance of randomly selected points from similar disturbances. Blair (1978) also found higher clutch sizes and greater hatchability at nests farther from human disturbance. Bechard et al. (1990) found that ferruginous hawks nested more than twice as far away from human habitation than red-tailed or Swainson's hawks (681 m and 769 m from red-tailed and Swainson's hawks, respectively, to human habitation, compared to 1,465 m from ferruginous hawks). Gaines (1985) found no effect until ferruginous hawks nested within 0.7 km of human habitation.

Urbanization

Bendire (1892: 260) reported that ferruginous hawks "shunned the settled regions"

Table 6. Mean intraspecific "nearest neighbor" distances for ferruginous hawk pairs for each year studied.

References	Study Years	Number of Nesting Pairs	Mean "Nearest Neighbor" (km)
Smith and Murphy (1978)	1967	15	
	1968	28	
	1969	34	2.5 [B]
	1970	13	
	1971	4	
Howard (1985)	1972	43	3.6
	1973	54	3.7
Lokemoen and Duebbert (1976)	1973-74	12.5 [a]	2.6 [b]
Blair (1978)	1976	24	7.2
	1977	17	6.4
Thurow et al. (1980)	1978	19	4.3
	1979	25	3.8
Gilmer and Stewart (1983)	1978	78	2.5
	1979	97	2.2
Lockhart et al. (1980)	1979	8	4.0
Lardy (1980)	1980	32	1.9
Ensign (1983)	1979	13	5.4
	1981	12	3.4
	1982	11	5.5
Meyers (1987)	1985	63	2.7
Harmata (1991)	1990	23	0.8
TOTAL NUMBER OF PAIRS		638	
MEAN "NEAREST NEIGHBOR" DISTANCE			3.4

[a] "Number of Pairs" not given for individual years.

[b] "Nearest neighbor" data not given for individual years.

Table 7. Home range size for ferruginous hawks.

Study		Method	n [a]	km^2
Smith & Murphy (1973) (UT)		Vis. Observ.	9p	5.3
		Vis. Observ.	5p	6.6
Wakeley (1978a) (ID)		Vis. Observ.	1m	21.7
		Vis. Observ.	1m	17.2
Platt (1984) (WY)		Telemetry	1m	3.7
		Telemetry	1m	9.8
Janes (1985)	Boardman Site (OR)	Vis. Observ.	6p	8.0
	Heppner Site (OR)	Vis. Observ.	10p	3.4
	Strevell Site (ID)	Vis. Observ.	13p	9.0
	Vernon Site (UT)	Vis. Observ.	14p	5.5
McAnnis (1990) (ID)		Telemetry	7m	9.9
Harmata (1991) (MT)		Telemetry	1m	6.2
AVERAGE			57p, 12m	7.0

[a] p = pair; m = male.

even before the turn of the century. Inaccessibility, presumably to humans and predators, in nest site selection by ferruginous hawks may be of overriding importance (Roth and Marzluff 1989). Although individual ferruginous hawk pairs may nest near small rural communities, some if not most populations are excluded for many km around dozens of large metropolitan areas (Denver and Fort Collins, Colorado; Salt Lake City, Utah; etc.) within their range to a greater extent than the red-tailed and Swainson's hawks. This was especially true of the Colorado population studied by Olendorff (1973, 1975).

The obvious exclusions of ferruginous hawks from areas with housing developments, business districts, and industrial complexes is only part of the problem. Radiating out from metropolitan areas is a broad band of suburbs, lower density housing, farming areas, and a complete life-support network of power lines, telephone lines, highways, pipelines, airports, recreation sites, etc. Olendorff (1973) reported

that the intensity of these human disturbances had to be relatively low before ferruginous hawks nested in Colorado.

Jasikoff's (1981) habitat suitability index model for ferruginous hawks assumed that if 10% of an area is disturbed, not necessarily developed, then the suitability index for ferruginous hawks would begin to decrease. If 75% or more of the area was disturbed, then the suitability index would be zero. The percentage disturbance may be even less if the land is cultivated (Schmutz 1984, 1987a, 1989a).

Cultivation

Young (1989) discussed effects of agriculture on raptors. The low use of cultivated land by ferruginous hawks as nesting habitat has been widely reported (Olendorff and Stoddart 1974; Howard 1975; Howard and Wolfe 1976; Cottrell 1981; Gilmer and Stewart 1983; Schmutz 1984, 1987a). Intensive agriculture renders native grasslands, shrublands, and pinyon-juniper forests less useful as ferruginous hawk nesting habitat (Olendorff 1973, Howard 1975, Blair 1978, Cottrell 1981, Gaines 1985, Schmutz 1987a, Roth and Marzluff 1989), though not necessarily as winter foraging habitat (Schmutz 1987e). Houston and Bechard (1984: 169) summarized the problem with cultivation and related activities in Saskatchewan as follows:

> "...plowing of the remaining native grassland continues, though at a slower pace than earlier in the century, simply because only marginal lands now remain uncultivated. As land prices rise, as cattle prices drop disproportionately, as farmers try to cultivate a larger proportion of their holdings, and as mechanical rockpicking machines allow cultivation of rocky grassland for the first time, less and less acreage remains each year in native grassland....Not only do ground squirrel numbers decline noticeably when large tracts of grassland are plowed, but once the shorter grasses are replaced by taller grain crops the remaining animals are more easily concealed...."

These effects translate directly to a decline in ferruginous hawk numbers. As cultivation on Schmutz's (1987a) study plots increased, ferruginous hawks decreased. There was a curvilinear relationship: ferruginous hawks increased in density where cultivation occupied up to 30% of the land; ferruginous hawks declined as cultivation rose above 30%. In fact, ferruginous hawks occupied areas of moderate cultivation (10-30%) at a greater density than they did 100% natural grass in Alberta (Schmutz 1989a). Declines were very apparent when more than 50% of the land was cultivated (Schmutz 1991).

Ferruginous hawks favor areas of grassland, shrubsteppe, and sparse pinyon-juniper forests (see section on Nest Site Characteristics in this report). In general, these areas are uncultivated grazing land, which if managed to keep trees and woody shrubs from invading, remain good for domestic livestock and ferruginous hawks. One must always be wary of 2 factors that destroy prairie: grasslands converted to cultivation and, in certain places, grassland fires being suppressed, thereby encouraging invasion by trees (Schmutz 1987c). Clearly, much of the ferruginous hawk's range in Canada has been overgrown by aspens invading from the north, and the effectiveness of fire management has allowed the invasion to take place (Schmutz 1987b).

In Washington ferruginous hawks nested where only 6.7% of the habitat was cultivated wheatland; red-tailed hawks nested in areas with 20.1% wheat; and Swainson's hawks nested where 50.4% was wheatland (Bechard et al. 1990). Ferruginous hawks nested in 2 grazed habitats (native grassland and shrub vegetation) and juniper forests at about equal rates. Swainson's hawks nested in native

grassland 25.2% of the time, whereas red-tailed hawks nested in shrub vegetation 57.5% of the time. Neither the red-tailed hawk nor Swainson's hawk nested in juniper forests.

Ferruginous hawks in North Dakota nested in 28.4% cropland and 25.9% hayland which is harvested 1 to 3 times per season (Gaines 1985). Hayland is an important habitat in North Dakota and South Dakota where ferruginous hawks commonly nest on transmission towers (Gilmer and Stewart 1983) and haystacks (Gilmer and Wiehe 1977; Table 3).

Only 1 of 71 ferruginous hawk nests studied in northeastern Colorado was in cultivated land--and the female of that pair had a falconer's jess on 1 leg indicating prior conditioning to human activity (Olendorff and Stoddart 1974). In northwestern Kansas, Roth and Marzluff (1989) found only 1 of 100 ferruginous hawk nests occurred where cropland was greater than 75%. Howard (1975) and Howard and Wolfe (1976) reported only 1 of 97 nests in southeastern Idaho and northeastern Utah had traces of cultivated land "in the vicinity." Similarly, cultivated lands were used as nest areas in eastern Oregon significantly less than expected on the basis of availability (only 1 nesting out of 46 occurred in farmland; Cottrell 1981). In the same area, red-tailed hawks used cultivated land extensively. In South Dakota, Blair (1978) found only 1 of 38 attempts in cultivated land, and it was unsuccessful.

Gilmer and Stewart (1983) noted very low ferruginous hawk densities in the Drift Plain biotic subregion in North Dakota, which is dominated by croplands, compared to the Missouri Coteau and Coteau Slope biotic subregions, which are characterized by high proportions of native eastern mixed-grass climax communities. However, Lokemoen and Duebbert (1976) and Gilmer and Stewart (1983) frequently found ferruginous hawks nesting on haystacks and other substrates adjacent to or in hayfields in the Dakotas. Many of these hayfields were unplowed native grassland, not alfalfa or other cultivated grasses.

Cultivated fields may provide foraging habitat for ferruginous hawks, particularly if the crop is low in height and/or supports high prey populations (Wakeley 1976, 1978a). Also, as crops grow in size, thereby increasing cover and decreasing prey vulnerability, ferruginous hawks shift to alternate hunting sites. In Utah, hawks foraged in alfalfa but nested near a juniper/sagebrush (*Artemisia*) steppe ecotone about 0.6 km from alfalfa fields (Wakeley 1978a). One heavily-used alfalfa field was infested with northern pocket gophers; another heavily used site was a combination of bare ground and pasture. Wakeley (1978a: 324) concluded that "...the density of vegetative cover was a more critical factor in the hawks' choice of hunting sites than was prey density."

Native hay lands and alfalfa fields, which are not plowed annually (Cottrell 1981), appear to be less detrimental to ferruginous hawk foraging than crops such as potatoes wheat, corn, and other grains. Small mammals, particularly pocket gophers, often increase in unplowed fields to the point that ferruginous hawks will forage there extensively (Wakeley 1978a). Smith and Johnson (1985) found that some Townsend's ground squirrels (*Spermophilus townsendii*) living in or near irrigated alfalfa fields reproduced during a drought year while those in native habitats did not. Nydegger and Smith (1986) stated that: "Conversion of native range to agriculture is detrimental to both black-tailed jackrabbits (*Lepus californicus*) and Townsend's ground squirrel populations through loss of habitat, disturbance, and control programs." One would infer from this a negative impact on ferruginous hawks due to loss of prey habitat.

The reason ferruginous hawks avoid frequently plowed fields for hunting involves a

combination of lower prey densities or availability in monotypic agriculture, absence of trees for nesting, and springtime activity of farmers--a time when raptors in general are susceptible to human disturbance. As the crop grows--plowed or not--prey becomes increasingly less vulnerable due to the concealment provided by crop height (Wakeley 1978a). If no other prey is available, and if it is not energetically efficient to feed several young at the nest, reproductive performance could be adversely affected.

Grazing

Kochert et al. (1988) and Kochert (1989) classified the effects of grazing on raptors into 3 types: changes in nest substrate availability, effects on prey abundance, and effects on prey vulnerability. Ferruginous hawks can be affected in all 3 ways, but quantification of such effects is difficult, and no definitive quantitative studies have been done to date.

Grazing management affects nongame bird populations and habitats both positively and negatively, as well as directly and indirectly (Buttery and Shields 1975, Kindschy 1978). Compared to urban areas and cultivated land, managed ranchlands frequently provide much better nesting and foraging conditions for ferruginous hawks. The combination of some ranchers being sympathetic to smaller raptors (if not eagles) in some areas (Colorado; Olendorff 1973) and the effects of their patrolling and/or signing of their property ("No Hunting, No Trespassing, No Nothin', No Foolin'!") yields thousands of ha of habitat for birds of prey and other wildlife.

There are, however, negative effects of the livestock industry on raptors, many of which can be mitigated through enlightened range management practices. Potentially negative effects stem from some rancher attitudes toward raptors; cattle distribution problems related to water, forage, shade, and other range conditions; improper stocking rates both in numbers and duration; rabbit and rodent control (see Impacts of Poisoning and Small Mammal Control); and land conversion and other range habitat improvements (see Land Conversion--Shrubland to Grassland).

<u>Rancher Attitudes</u>. According to my studies in Colorado (Olendorff 1973) and the studies of J. M. Marzluff (Greenfalk, Boise, Idaho, pers. commun.), many ranchers enjoy raptors, such as ferruginous hawks, as integral parts of the rural/pastoral setting in which they choose to live and work. Many ranchers are proud of their hawks, and they recognize that hawks eat rabbits, ground squirrels, prairie dogs, pocket gophers, mice, rats, and insects--all of which eat the plants and seeds that produce forage needed for livestock. On the other hand, the few ranchers who carry rifles and use them to implement even a casual or opportunistic "varmint" control program can enact a heavy local toll on raptors.

<u>Cattle Distribution</u>. The consideration of grazing as 1 of the 5 ultimate causes of ferruginous hawk population declines involves primarily its impact on nesting trees, but overall habitat degradation due to overgrazing is also a consideration (Stewart 1975). Tree seedlings in riparian and other areas are frequently eaten by cattle, thereby precluding replacement of the over-mature and decadent trees often used by raptors as nest substrates (Kochert et al. 1988). Healthy trees are killed by cattle which, in seeking shade, trample the trees' root systems and in rubbing against the trees' bark to scratch, girdle some trees through the abrasion (Olendorff 1973; Fig. 5). These problems are not as prevalent in pinyon-juniper forests (C. M. White, Brigham Young Univ., pers. commun.).

<u>Improper Stocking Rates</u>. Problems related to the overstocking of available rangelands, such as soil erosion, lowering of water tables, and poor subsequent forage

Fig. 5. Trees rubbed against and with root systems trampled by cattle. The downed trees were stacked around the ferruginous hawk nest tree to keep the cattle away. The pole overlooking the nest was for mounting a time-lapse camera. Photograph by J.R. Craig.

production all affect raptors indirectly through prey populations (Kochert et al. 1988, Kochert 1989). Small birds and mammals -- i.e.,ferruginous hawk prey--are highly sensitive to habitat changes brought on by grazing, but the effects can be positive or negative depending on the prey species involved (Kochert et al. 1988, Kochert 1989). Wiens and Dyer (1975) and Kantrud and Kologiski (1982) found that the effects of grazing on grassland birds depended on many factors, such as the original plant structure, soil types, and climatic factors.

Flinders and Hansen (1975) showed that white-tailed jackrabbits (*Lepus townsendii*) were not significantly affected by grazing intensity. Desert cottontails (*Sylvilagus auduboni*), however, were more abundant in pastures moderately grazed in summer and winter; black-tailed jackrabbit populations were lower in pastures with higher summer grazing intensities. This lowering of the rabbit population could adversely affect ferruginous hawk density and productivity. In Oklahoma, jackrabbits, pocketgophers, and deer mice (*Peromyscus* sp.) were most abundant in

"moderately overgrazed" areas, whereas cottontails preferred ungrazed areas (Phillips 1939). However, in "heavily overgrazed" pastures rodent and lagomorph numbers were reduced thereby decreasing the overall raptor prey.

Other studies have addressed the effects of grazing on mice, voles (*Microtus sp.*), kangaroo rats, and small birds which sometimes fall prey to ferruginous hawks (Kochert et al. 1988, Kochert 1989). Kochert (1989) reported that small mammals and birds that require a low level of cover are favored more by grazing than those that need substantial cover (i.e., *Microtus* sp.); those that are typical of xeric habitats tend to be favored. In general, heteromyid and geomyid rodents and granivorous prey species may be more tolerant of grazing.

In Utah, deer mice were more prevalent in heavily grazed areas; harvest mice (*Reithrodontomys* sp.) and pocket mice (*Perognathus* sp.) were more abundant in ungrazed areas containing introduced grasses (Black and Frischknecht 1971). In Arizona, Monson (1941) discovered over twice as many small birds--and a greater diversity of species--in ungrazed as opposed to overgrazed areas, though Reynolds and Trost (1981) showed similar densities and diversities of nesting birds in grazed and ungrazed sagebrush. Owens and Myres (1973) found that different passerines dominated lightly as opposed to heavily grazed shortgrass prairies in Alberta, but meadowlarks, the major avian prey species of ferruginous hawks, were equally common under both conditions. Reynolds (1958) found Merriam's kangaroo rats (*Dipodomys merriami*) most abundant on heavily grazed ranges in Arizona where a reduction of perennial grass densities had occurred.

Studies generally show offsetting negative and positive effects of grazing on species used by ferruginous hawks as prey. To the extent that improper stocking of cattle may reduce the long-term capability of land to produce a large biomass of prey, such abuse is also bad for raptors. Yet, to the extent that overgrazing increases certain prey densities as well as vulnerabilities by eliminating protective cover (Kochert et al. 1988), short-term benefits to raptors may be provided. Management for short-term benefits is illogical, however, in light of the possible catastrophic long-term negative effects on the fundamental capability of land to produce.

Land Conversion--Shrubland to Grassland

Most lands inhabited by ferruginous hawks are managed primarily as rangeland for domestic livestock grazing (Olendorff 1973, Howard and Wolfe 1976, Cottrell 1981, Roth and Marzluff 1989). Improper grazing brings a gradual downward trend in perennial grass density and increases in annuals and woody species in some areas (Kochert et al. 1988, Kochert 1989). These trends are frequently counteracted by range improvement practices, such as sagebrush control, grass seeding, prescribed burning, implementation of grazing systems, etc. (Kochert 1989).

Except for occasional direct destruction of ferruginous hawk nests (Howard and Powers 1973), the net effect of most conversion of shrubland to grassland is a decrease in vegetative diversity, as well as horizontal and vertical structure. Although this may make prey more vulnerable in the absence of cover, it decreases habitat richness, prey species diversity, and prey population stability (Reynolds and Trost 1981, Maser and Thomas 1983). Unfortunately, the large-scale land conversions conducted between 1934 and 1981 in southeastern Oregon were not followed with quantitative studies of the responses of ferruginous hawk prey species, such as jackrabbits, ground squirrels, and pocket

gophers (Lardy 1980). The quantification of such effects remains a fruitful avenue of research (Howard and Wolfe 1976).

Only a few studies (see below) shed indirect light on the effects of conversion of shrubland to grassland on the major ferruginous hawk prey groups: ground squirrels, pocket gophers, rabbits, and hares. The matter is complicated, since evidence suggests that not all effects are negative, including those related to prey resources. In fact, some data are conflicting.

Howard and Wolfe (1976: 36) stated that "...past crested wheatgrass (*Agropyron desertorum*) seedings have not adversely affected the reproduction of ferruginous hawks. However, the hawks used different prey in seedings as opposed to native desert shrub habitats." Data indicated a strong potential for ferruginous hawks to prey on jackrabbits in desert shrub, but on pocket gophers and ground squirrels in crested wheatgrass and alfalfa. Jackrabbit numbers were generally higher in desert shrub habitats. Westoby and Wagner (1973: 349) noted that "...jackrabbits appear to favor habitats which provide an interspersion of tall cover with open space" and heavily used the edges between crested wheatgrass treatments and sagebrush stands, with no appreciable loss in use of areas seeded with crested wheatgrass over untreated areas. In Utah, rodents increased in chained and seeded areas for 2 years, but declined and then levelled off in succeeding years (Baker and Frischknecht 1971). Lardy (1980) stated that ground squirrels became abundant in the Vale, Oregon, area shortly after some areas, but not all, were converted from native vegetation to crested wheatgrass during the mid to late-1960's. Areas converted to crested wheatgrass may have made ground squirrels more drought resistant (through a more constant food supply) than those in cheatgrass (*Bromus tectorum*) areas. The resulting greater prey survival is speculated to translate to less fluctuation of ferruginous hawk productivity and less fluctuation in overwinter survival of the hawks in response to drought cycles. This scenario is countered by the fact that the Townsend's ground squirrel populations in Lardy's (1980) study area have subsequently crashed and never recovered (R. Kindschy, Bur. Land Manage., pers. commun.).

Perkins and Lindsey (1983) found a ratio of 3.2 unused to 1 used ferruginous hawk nests in areas of native vegetation compared to 24.2 to 1 in areas close to land converted to crested wheatgrass. They believed this to be the result of too few prey to sustain a greater number of nests in areas close to vast monotypes such as crested wheatgrass seedings (Perkins and Lindsey 1983), though other unstudied factors may have caused this discrepancy. The occurrence of numerous unoccupied ferruginous hawk nests (sometimes incorrectly interpreted as evidence of recent decline) may not be a recent phenomenon at all. Rolfe (1896) reported only 25 of about 200 presumed ferruginous hawk nests being used.

As further evidence of the negative effects of conversion of brushland to grassland on the small mammal populations in the Cedar Valley, Utah, where large areas were converted from sagebrush to grass, Murphy (1978) noted increased nesting failures of ferruginous hawks attributed to inability to supply nestlings with adequate food.

Shrub density was also important to black-tailed jackrabbits and thus to ferruginous hawks because of the cover and food provided. Big sagebrush (*Artemisia tridentata*) and black greasewood (*Sarcobatus vermiculatus*) cover types were particularly important, whereas winterfat (*Ceratoides lanata*) and grassland types did not support black-tailed jackrabbits in the Idaho study area (Nydegger and Smith 1986). The importance of shrubs to jackrabbits is corroborated by Maser et al. (1984).

Poisoning and Small Mammal Control

The use of anticoagulants and other rodenticides, jackrabbit roundups, and other methods of small mammal control affect ferruginous hawk populations indirectly through their food supplies. Secondary poisoning of raptors is known (e.g., Borg et al. 1970, Newton 1979, Schmutz et al. 1989), but it has not been identified as a serious problem in ferruginous hawks. Poisoning campaigns produce local food shortages because they are usually directed at key ferruginous hawk prey species, such as ground squirrels and prairie dogs (Schmutz and Hungle 1989). Food shortages may lead to interruptions in breeding, decreased productivity (smaller clutch size, starvation in large broods, etc.; Smith et al. 1981), and increased susceptibility of breeding ferruginous hawks to human disturbance (White and Thurow 1985).

The extent to which rodent control activities have occurred in the western United States since the turn of the century is well documented (Schmutz and Hungle 1989). Effects can occur in a single season, thus lessening their seriousness, or they can be permanent (e.g., total poisoning of a prairie dog town) and therefore a more profound ultimate cause of ferruginous hawk population decline. No poisoning or other control program, be it directed against prairie dogs, ground squirrels, pocket gophers, kangaroo rats, or lagomorphs, is without consequence to organisms of higher trophic levels.

Mining

The need to mitigate impacts of mineral, oil, gas, coal, and geothermal development has spawned several studies and analyses of ferruginous hawk biology (Platt 1984, 1985, 1986, Stalmaster 1988, Harmata 1991). Evans (1980) listed 3 principal negative impacts of mining: loss of nesting areas, loss or severe reductions in prey populations, and nest desertions caused by human disturbance. These impacts are of varying importance during different phases of mining and drilling as listed by Benson (1979): exploration (aerial reconnaissance, off-road travel of large trucks, seismic explosions, exploratory drilling); extraction (overburden removal, strip mining, well drilling, dynamite blasting, other noises); processing (pumping of oil, crushing of ore, grading and stockpiling coal, generating of electricity from geothermal wells); and transportation (roads, railroads, pipelines, power lines, conveyor belts, etc.).

The unmanageable indirect impacts of mining may be even more troublesome for ferruginous hawks than mining itself (Evans 1980). Energy development requires that thousands of people reside relatively close to the resource. This means new housing, businesses, support facilities, additional or upgraded transportation routes, and recreational opportunities. The latter, in particular, may place people in direct contact with nesting raptors, resulting in nest desertions, indiscriminate shooting, and many other detrimental activities.

Harmata (1991) found that ferruginous hawks with high productivity (3 or more young) were nearly twice as far away from active wells (1,159 vs. 690 m) than nests with low productivity (2 or less young). Daily maintenance on active wells may disrupt nesting hawks and reduce productivity. Occurrence of raptors away from nests was more a function of proximity to prey and hunting perches than avoidance of oil and gas development. Lockhart (1979) and Lockhart et al. (1980) found that nearly 60% of all ferruginous hawk nests in a 622-km^2 study area in Sweetwater County, Wyoming, were within 1 km of proposed coal strip mines.

Fire and Fire Management

Fires can destroy ferruginous hawk nests (Bendire 1892, Davy 1930) or alter habitat around nests. Nests on steel transmission line towers, however, protect ferruginous hawks from fire (Steenhof et al. 1993). Houston and Bechard (1984) and Schmutz (1984) listed control of wild fires as an important cause of ferruginous hawk decline in southern Canada. Lack of fire has allowed aspen clumps to regenerate, resulting in a habitat more suitable to red-tailed hawks. Grazing, fire suppression, and other factors have also produced large areas of dense pinyon-juniper forests in the Great Basin of the western United States (Dealy et al. 1981). This may have had a similar negative effect on ferruginous hawk populations, because the species does not nest in the interior of large forests. Rather, they nest near edges between forests and shrubland or in sparse tree/shrub communities.

The effect of fire is double-edged; although fire may maintain proper interspersion of trees, shrublands, and grasslands for tree-nesting birds, it also decreases the structure provided by the shrub component of the habitat which is so important as cover and food for some ferruginous hawk prey species.

The choice between short-term losses of cover and food for prey species and long-term maintenance of nesting habitats is a fundamental question in ferruginous hawk management involving either wild fire control or prescribed burning. LeFranc and Glinski (1988) called for research on prescribed burning techniques, the inclusion of let-burn policies in land management plans, and the use of prescribed burning as a management tool to combat the negative trends to ferruginous hawk habitat (pinyon-juniper loss in the southwest United States and increase of prairie parkland in Alberta).

Other Activities

Roads and Railroads. Railroads apparently do not affect ferruginous hawk populations significantly (Rolfe 1896, Stalmaster 1988). The road bed removes a small area of prey species habitat, and activities near the tracks may divert ferruginous hawk feeding sorties into other areas. Neither of these impacts appears severe, but there are records (U.S. Bur. Land Manage., unpubl. data) of ferruginous hawk fledglings being killed by trains.

Along the coal-hauling Deseret-Western Railway in Rio Blanco and Moffat Counties, Colorado, and Uintah County, Utah, 28 of 140 nesting attempts (20%) were within 1 km of the railway (Stalmaster 1981, 1982, 1983, 1984). However, following the eighth year of this monitoring study, no significant impacts of construction, operation, or maintenance of the railway had been noted (Stalmaster 1988). The discrepancies in ferruginous hawk nest occupancy (occupancy at a significantly higher rate with increasing distance from the tracks) were present in baseline studies before the railroad line was built.

New roads, on the other hand, provide access to otherwise relatively inaccessible land where even limited access by humans can affect the ferruginous hawk. Bechard et al. (1990) showed that ferruginous hawks nested further from primary roads than Swainson's hawks (ferruginous hawks--1,210 m, Swainson's hawks--717 m). A similar trend was noted for secondary roads (ferruginous hawks--488 m, Swainson's hawks--259 m). In contrast, Gilmer and Stewart (1983) found that the nesting success of 58 pairs within 500 m of an interstate highway or well-travelled roads was similar to that of all other pairs (n = 571). They felt the birds acclimated to this type of disturbance.

Ferruginous hawks are killed by collisions with automobiles where roadkilled jackrabbits are abundant. The hawks feed on carrion (Murie 1934, Olendorff unpubl. data) and are sometimes struck by speeding vehicles (Howard 1975).

Recreation. The mobility provided by 4-wheel drive and other off-road vehicles can be a potential threat to ferruginous hawk populations. The topographic relief provided by ferruginous hawk nesting habitat is often great enough to provide a challenge to motorcyclists and 4-wheel enthusiasts. Areas chosen for intensive off-road vehicle use will probably preclude ferruginous hawk nesting, because noise and more subtle disturbances affect ferruginous hawks physiologically (increased heart rate; Busch 1977, Busch et al. 1978).

Shooting/Persecution. Early in this century persecution of raptors was widespread (Houston and Bechard 1984). Bent (1937: 285) stated that this persecution reduced the ferruginous hawk "...to the verge of extinction, and allowed the ground squirrels to increase." Although Bent may have understated the status of the ferruginous hawk, persecution (including shooting) of raptors by early settlers of western North America had a negative effect on many species. However, shooting normally has only a minimal effect which can be compensated by a species' productivity (Newton 1979).

The shooting of 1 or few ferruginous hawks has been reported often (Bendire 1892, Cameron 1914, Davy 1930, Salt 1939, Ellis et al. 1969, Howard 1975, Fitzner et al. 1977, Benson 1981, Harmata 1981, Olendorff unpubl. data). However, Houston and Bechard (1984: 169) noted that the significant decrease in the rate of band recoveries from Salt's 1930's data (Salt 1939) to their own 1970's data "...was due in large part to a decrease in the numbers of hawks shot in the past 40 years."

Shooting may still be a problem on the wintering grounds of ferruginous hawks. Band returns frequently list shooting as the cause of death (Harmata 1981, Gilmer et al. 1985). Chesser (1979) noted that his rifle fire attracted 5 ferruginous hawks to a prairie dog colony at which he was collecting prairie dog specimens. All of the hawks could have been easily shot.

Power Lines. Peacock (1980) documented the electrocution of a ferruginous hawk, but neither electrocution on nor collisions with power lines is a significant mortality factor of ferruginous hawks (Olendorff et al. 1981). For a complete review of raptor electrocution and its potential effects on raptors see Olendorff et al. (1981). Utility lines along roads do increase the susceptibility of ferruginous hawks to shooting, but this effect has been reported to be minimal (Benson 1981). Construction impacts may be severe during a single nesting season. Most other impacts of power lines are positive (perching, roosting, nesting; Steenhof et al. 1993), a circumstance for which the electric industry should be commended.

HABITAT MANAGEMENT RECOMMENDATIONS

Management of ferruginous hawks and their habitats must be based upon adequate nest substrates, stable and sufficient food resources, and freedom from direct disturbance. When these general habitat characteristics occur in proper juxtaposition in potential habitat for ferruginous hawks, management should maintain their numbers or, potentially, establish new populations.

Management of Nest Substrates

Management in the immediate vicinity of a nest may involve both maintenance and enhancement. The goal of such management should be nest site quality and variety first, quantity second. Most of the recommendations

which follow are relatively inexpensive to implement considering the high potential for positive results. For example, Anderson and Follett (1978) and Craig and Anderson (1979), using a combination of the following techniques, observed greater ferruginous hawk productivity--3.1 young per attempt compared to 1.6 and 1.8 in 2 unmanaged areas.

Managers must realize, however, that breeding potential is not the parameter at which management programs should be directed. Clutch size is largely inherent to the species, though it depends partially on food supply and weather (Newton 1979). The number of young per successful attempt does not offer significant room for improvement because it is an average of just the successful pairs, leaving unsuccessful pairs out of the calculation. Rather, management must be applied in 2 different directions. First, existing habitats must be maintained through site protection and enhancement, thereby increasing nesting success (the percentage of pairs which produce at least 1 young). Second, new habitat must be created, particularly where prior extirpations of ferruginous hawks have occurred. This can be accomplished by installing artificial nest structures, considering ferruginous hawk nesting requirements in land-use decisions, and ensuring adequate replacement of nest trees through natural processes. The effectiveness of reaching goals for ferruginous hawk management can be measured by comparing the density and nesting success of pairs nesting in a managed area to baselines obtained before management and/or for control populations where no management is undertaken.

Management Recommendation No. 1. **Ensure that a variety of nesting opportunities for ferruginous hawks exists within each management unit.** Only about 6% of 2,119 ferruginous hawk nest sites reported in the literature were on the ground (Table 3); all others were on cliffs, in trees or shrubs, on rock or dirt outcrops, or on utility structures. A combination of small cliff modifications (e.g., creation of ledges; Fyfe and Armbruster 1977), conservation of trees, and/or alterations of artificial structures can significantly increase the availability of nest sites for raptors in general and ferruginous hawks in particular (Olendorff and Stoddart 1974).

Management Recommendation No. 2. **Rearrange the structure of existing nests during the non-nesting season to reduce the probability of falling or being blown down (Craig and Anderson 1979).** Ferruginous hawks build heavy, bulky nests that are frequently destroyed by spring and summer wind storms (Olendorff 1973, Woffinden 1975, Gilmer and Wiehe 1977, White and Thurow 1979, Thurow et al. 1980, Powers 1981). Because these hawks often nest in solitary dead or dying deciduous trees (Olendorff 1973), wind resistance is a serious problem. By removing 1 or more layers of nest material, weight and wind resistance can be reduced. Shifting the nest base more toward the central axis of the substrate may also help (Craig and Anderson 1979). This should be done in the early fall after the occupants have dispersed and before winter cold makes the trees brittle and even more susceptible to blowdown.

Management Recommendation No. 3. **Reinforce the bases of weak or unstable tree nests with wire mesh, netting, or lumber to increase their longevity (Anderson and Follett 1978, Craig and Anderson 1979).** Wrapping the nest base in wire netting or inserting a few supporting boards into the nest structure and wiring them to the branches are easy and inexpensive methods of improving nest stability.

Management Recommendation No. 4. **Trim branches in trees and around nests to provide the adult birds with good access to nest sites and well-placed perches (Craig and Anderson 1979).** Many trees with dense branches may not allow direct access for

ferruginous hawks to branch configurations suitable to support a nest. A proper arrangement of perches and open access can be provided by selective pruning of trees, but over-pruning immediately around and beneath the nest may increase detectability by humans and predators.

Management Recommendation No. 5. **Stabilize/reinforce snags that hold nests to keep them standing as long as possible.** The functional effectiveness of dead trees may be extended by judicious use of wood preservatives and/or lashing trees to wooden poles set in concrete immediately adjacent to the tree. These management strategies may be necessary to keep ferruginous hawk nests in use until hawks can habituate to the presence of an artificial structure or until planted trees mature sufficiently to provide nesting substrate.

Management Recommendation No. 6. **Build artificial nests or place wire baskets in available trees to encourage more nesting by ferruginous hawks in existing, otherwise natural situations (Olendorff and Stoddart 1974).** Such structures should be out of view of passing humans, and far removed from sources of disturbance (e.g., roads, plowed fields, residences, etc.). Care must be taken not to encourage nesting by great horned owls (*Bubo virginianus*) which nest earlier than ferruginous hawks and depend on stable nest sites built by or intended for other species. These owls usually are able to displace ferruginous hawks from the better nests, usually in trees (Olendorff 1973, Blair 1978). In some cases, 2 nests (far enough apart to prevent predation) may require enhancement: 1 for owls and 1 for hawks. The hawk nest may require partial dismantling each fall to discourage owl nesting the following spring (Olendorff and Stoddart 1974). The hawks will rebuild nests; the owls will not (Olendorff 1973).

Bohm (1977) described a design for artificial nest baskets. Baskets were made of 2.54 cm (1-inch) mesh chicken wire formed into a shallow cone. The cone was then lined with tar paper and provided with a drainage hole at the base. An artificial nest consisting of twigs, leaves, and branches, with finer material near the top where the eggs would be laid was built in each basket. Once the entire nest was complete, it was attached in a suitable crotch of a tree.

Although Bohm (1977) placed such baskets for great horned owls and red-tailed hawks in central Minnesota, other researchers have used them for ferruginous hawks. Call (1979b) installed 3 baskets on the Pawnee National Grassland in northeastern Colorado in early 1979. Two of the 3 were used by ferruginous hawks that same year. In 1971, Fyfe and Armbruster (1977) erected wire baskets for ferruginous hawks in 5 areas in Alberta where old nests had been destroyed. Four of these nests were occupied in 1972. By 1975, 37 baskets had been erected, 22 in former raptor territories and 15 in grassland areas with adequate prey but no previous record of occupancy. Ferruginous hawks nested in 16 (43%) of the 37 baskets, indicating the effectiveness of the technique. Most of the occupancy was in former ferruginous hawk territories.

Management Recommendation No. 7. **Erect artificial nesting platforms in suitable habitat.** This is particularly useful in previously used territories where all available trees have died and fallen, in large areas that have been converted from tree/shrub communities to grass/shrub communities, or where availability of nest sites is a natural limiting factor (Olendorff and Stoddart 1974, Fyfe and Armbruster 1977). An occupancy rate of 15% to over 50% of available platforms can be expected per year within 2 to 4 years after they are installed (Schmutz et al. 1984, Houston 1985, Call and Tigner 1991).

Artificial structures intended for ferruginous hawks should not be visible from other *Buteo* nests. Cottrell (1981) found that such visibility adversely affected ferruginous hawk nesting success in Oregon, as did Schmutz et al. (1980) for all *Buteo* species in Alberta that nested less than 0.3 km from congenerics.

Platform designs vary from study to study, but the following description provides the basic concepts (Schmutz 1977, 1983, 1984). Nest platforms consisted of either a wooden box (120 x 60 x 20 cm) with 2.54-cm welded wire mesh as a base or a basket of welded wire approximately 60-90 cm in diameter and 20 cm deep. The box/basket was filled with shrubs and/or grasses depending on availability. Nesting material was secured by fastening 2 to 4 branches across the top. The platform was mounted on a wooden pole, 20-30 cm in diameter at the base, atop 2 "V"-shaped supports of lumber (3.8 x 10 cm) that formed a triangle against the pole (Schmutz 1977, 1983; Figs. 6 and 7). Height of the nest platform above ground ranged from 1.9 to 4.3 m. Some shade and protection from wind was provided by placing the structures adjacent to trees or shrubs, by having the wooden pole extend above the nest platform, and/or by attaching a wooden wind barrier, 45 cm high, to the south side of a nest platform. For more detailed specifications see Schmutz (1983).

Management Recommendation No. 8. If land is converted from tree/shrub communities to grassland or grassland/shrub communities, leave individual trees, a mosaic of stands of trees, or a thin scattering of trees as nest sites for ferruginous hawks (Howard and Wolfe 1976, Murphy 1978). In 12 of 22 studies throughout the western United States and Canada, trees have been used as nest substrates by ferruginous hawks more often than any other type (Table 3). Thus, total elimination of trees over large areas decreases nesting opportunities for ferruginous hawks. Howard and Wolfe (1976: 36) recommended that when juniper communities are chained, "...some trees should be left on the perimeter of and interspersed in small islands throughout the treatment area to provide nest sites." Woffinden and Murphy (1983a) emphasized the importance of isolated trees to ferruginous hawks, and suggested that the protection of single junipers scattered throughout treatment areas would significantly increase the number of potential ferruginous hawk nest sites with very little detrimental impact on range improvement practices.

In Alberta, if all nesting *Buteo*s are present, at least 4 small clumps of trees per 2.6 km^2 (1 mi^2) of habitat are necessary to maximize nesting by all *Buteo*s (Schmutz et al. 1980). Though greater interspersion of trees, shrubs, and grasses may be necessary to maintain adequate prey resources, the number of breeding *Buteo*s depended on the availability of suitably spaced trees. "However, as the number of trees increases, the number of nesting pairs also increases but reaches an upper limit, probably determined by the territoriality of resident pairs" (Schmutz et al. 1980: 1084).

Management Recommendation No. 9. Ensure that young naturally growing or planted trees survive in ferruginous hawk territories to provide future nest substrates. Grazing and the rigors of the arid environments inhabited by ferruginous hawks combine to eliminate most tree seedlings (Kochert et al. 1988, Kochert 1989). Mature riparian forests (especially cottonwood [*Populus* sp.] forests) are not being replaced with sufficient regularity (Kochert et al. 1988, Kochert 1989). Likewise, the numbers of exotic trees planted by early farmers are decreasing (Olendorff 1973). Seedlings nearly always face unacceptable conditions without watering and nurturing, and many large older cottonwoods, Russian olive trees (*Elaeagnus angustifolia*), and locust trees (*Robinia pseudo-acacia*) are dead or dying owing to the absence of homesteaders.

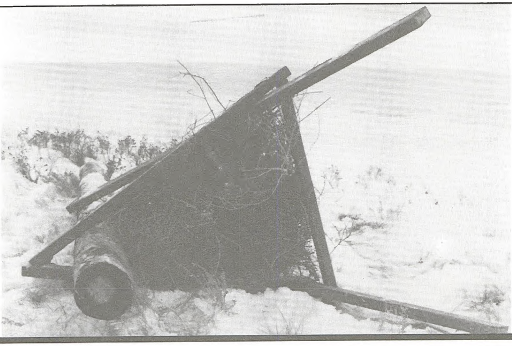

Fig. 6. Ferruginous hawk artificial nest structure on the ground before being installed. Photograph by J.E. Schmutz.

Fig. 7. Ferruginous hawk artificial nest structure being hoisted into position. Photograph by J.E. Schmutz.

Two approaches for encouraging successful growth of replacement trees are planting trees in fenced enclosures (Olendorff and Stoddart 1974) and fencing of small areas where tree sprouting would be possible in the absence of cattle grazing and other surface disturbances (Wagner 1980, Kochert et al. 1988). Ferruginous hawks do not need planted forests; a scatter pattern of small groups of trees is sufficient if food resources and freedom from disturbance are adequate. Such planting is relatively inexpensive when performed by volunteers, scout troops, work release prisoners, or youth conservation corps.

Management Recommendation No. 10. **Fence ferruginous hawk nest trees and snags where they are threatened by cattle seeking shade or using them as rubbing posts (Olendorff and Stoddart 1974).** Cattle destroy sod around the trees, and winds blow the soil away. This exposes the tree's roots and, coupled with abrasion of the bark from rubbing by cattle, kills them (Fig. 5). Such trees should be fenced in small enclosures (3 m by 3 m for individual trees, larger only if necessary for small groves of trees). Very little grazing land is sacrificed (less than 10 m^2 per tree), and an attraction (shade) that concentrates cattle is largely eliminated. This has been a common practice on some National Grasslands administered by the U.S.Forest Service (Olendorff and Stoddart 1974).

Management of Prey Resources

Maintenance or enhancement of prey populations must be a principal concern of land owners who manage habitat with high numbers of raptors (Wagner 1980). Data suggest that farming, ranching, and other human activities, as well as changes in natural systems, such as cycles, irruptions, etc., that affect populations of ground squirrels, rabbits, hares, and pocket gophers also affect ferruginous hawk population dynamics. When prey populations decline, raptor populations can be affected in many ways (Newton 1979):

(1) breeding densities decrease (reported by Woffinden and Murphy 1977a, Thurow et al. 1980, Cottrell 1981, Smith et al. 1981, Ensign 1983);

(2) fewer nesting pairs lay eggs (reported by Cottrell 1981);

(3) fewer pairs renest successfully in the same year (reported by Howard and Wolfe 1976, Cottrell 1981, Smith et al. 1981);

(4) clutch size and brood size decrease (reported by Woffinden 1975, Howard and Wolfe 1976, Woffinden and Murphy 1977a, Smith and Murphy 1978, Smith et al. 1981, Ensign 1983, Steenhof and Kochert 1985, Stalmaster 1988); and

(5) parental attentiveness to young is weaker (reported by Woffinden and Murphy 1977, Ensign 1983. White and Thurow 1985).

A possible physiological cause of some of the decreased productivity following prey decline was given by Tomback and Murphy (1981: 96): "...the temperature fluctuations of the underfed nestlings at the Cedar Valley nest in 1977 and the significantly higher and more varied body temperatures of the underfed nestlings in 1979 suggest that food deprived nestling Ferruginous Hawks cannot cope with heat stress.... Heat prostration may be a major cause of nestling deaths under such conditions."

Management of prey resources to maximize ferruginous hawk productivity must consider plant communities and plant structure. Important forces include land conversion

(shrubland to grassland) and cultivation, various range improvement methods, and fire (both naturally occurring and prescribed). In general, if the latter 2 forces can be directed toward maintaining diverse and stable plant communities (and thus diverse and stable populations of rodents, lagomorphs, and small birds), then the goals of habitat management for ferruginous hawks will also be reached.

Management Recommendation No. 11. **When converting land from sagebrush steppe to grassland (e.g., to crested wheatgrass), leave a mosaic of treated and untreated areas.** Converting sagebrush to grassland is frequently done to increase livestock forage; however, the effects of such on ferruginous hawk biology are not well understood. The following discussion is meant to guide biologists in their attempt to salvage something for ferruginous hawks out of livestock management efforts.

Treat irregular patches 600 m or less in width, and provide interspersion of sagebrush stands to maximize edge effects (Howard and Wolfe 1976, Benson 1979). Westoby and Wagner (1973) found that jackrabbits frequently used edges (within 300 m) between crested wheatgrass seedings and sagebrush. The hares were able to feed in the crested wheatgrass yet escape with regularity to the cover of sagebrush whenever necessary. Bolen (1975) pointed out that lagomorphs were more easily exploited by predators where brush cover was the lightest, even though they were less plentiful in such areas. It is unclear what effect the creation of a mosaic would have on other ferruginous hawk prey (e.g., ground squirrels, northern pocket gophers, and kangaroo rats).

Interspersion of islands and peninsulas of sagebrush within grasslands (as opposed to squarish treatments) and leaving at least 20% of the total area in existing shrub/tree habitat (Howard and Wolfe 1976) provide a compromise between increasing livestock forage yields and possibly better ferruginous hawk habitat. Such interspersion also presents a more pleasing visual effect which is often required by land managing agencies.

Management Recommendation No. 12. **If land conversions, such as chaining, discing, plowing, or burning are done, conduct the treatments during the non-nesting season to avoid direct impacts to ferruginous hawks and their prey species during the reproductive season (Howard and Wolfe 1976, Benson 1979).** This generally means no treatments between 1 March and 1 August each year (see Management Recommendation No. 22). Of particular importance is avoidance of the early nesting period when ferruginous hawks are especially prone to abandonment after disturbance at their nest sites (Powers et al. 1975).

Management Recommendation No. 13. **Following chaining, windrow the brush to provide nesting habitat for small birds and cover for rabbits, hares, rodents, and small birds (Benson 1979).** Management of cover as wildlife habitat is discussed in detail by Yoakum et al. (1980).

Management Recommendation No. 14. **When reseeding chained or burned areas, use mixtures of seeds of naturally occurring plants to promote habitat diversity.** Habitat diversity generally leads to habitat stability, a situation that is beneficial to both ferruginous hawks and their prey.

Management Recommendation No. 15. **Develop and implement rest rotation or deferred rotation (Kochert 1989) grazing systems that do not allow overgrazing in stable, productive livestock pastures.** Excessive soil compaction, soil erosion, invasion of noxious weeds and undesirable annual grasses, and decreased capacity for regrowth of desirable plant species are all characteristic of overgrazing (Yensen 1982).

Because more intense use of habitat, such as for cultivation or urbanization, is generally detrimental to ferruginous hawks (see earlier sections), the future of ferruginous hawk populations depends largely on less intense land use, such as grazing. Thus, long-term deterioration of western rangelands serves neither the livestock industry nor the ferruginous hawk.

Management Recommendation No. 16. **If lagomorph or rodent populations must be controlled, as is often done to protect agriculture, decrease their numbers, but do not eliminate them.** Controlling small mammal populations is generally a controversial practice. However, if control must be done, for whatever reason, it should be aimed at lowering the peaks of cyclic highs or decreasing (not eliminating) areas occupied by colonial species, such as prairie dogs. Use of anticoagulants, strychnine, 1080, and other means may result in total eradication of some species of small mammals and a permanent change in predator-prey relationships that may also eradicate or significantly diminish predator populations. Raptors can also be affected through secondary poisoning, such as is caused by the use of strychnine and thallium sulfate (Newton 1979). Such activities are inconsistent with habitat management to enhance ferruginous hawk populations.

Management Recommendation No. 17. **When deactivating electric distribution lines or telephone lines, leave poles and crossarms for hunting perches.** Telephone poles, electric transmission towers, electric distribution poles, and fence posts have altered the hunting strategies of dozens of species of raptors by making millions of hectares of habitat available for hunting from a stationary perch (Williams and Colson 1989).

Power and telephone companies often remove obsolete lines. One cost-saving measure that would also benefit raptors, such as ferruginous hawks, is to remove lines but leave half or more of the poles and crossarms in key hunting habitats. Christensen (1972) reported considerable raptor use of a deactivated telephone line in north central Utah. Most wildlife biologists could give utility companies advice on which poles to leave. Poles immediately adjacent to roads, where indiscriminate shooting may occur, should not be left standing.

Similarly, new perch poles can be erected near concentrations of prey species to provide ferruginous hawks access to prey and to decrease energy expended for hunting by the hawks. Ferruginous hawks used 2 poles erected by the Bureau of Land Management in large prairie dog towns near Saguache, Colorado (Snow 1974), but the use was not quantified. A Utah study showed that there was a significant reduction of pocket gophers near artificial perches, but the total impact of raptor predation on the gopher population was not clear (Christensen 1972). This technique remains a prime candidate for future management research aimed at quantifying its value as a biological control for pocket gophers, ground squirrels, and prairie dogs.

The design of artificial perches is mostly a matter of using available materials, but probably nothing is better than the top of a large fencepost or utility pole. Powers (1981) observed that ferruginous hawks used wooden fence posts more often than metal ones and large posts more often than small ones. These parameters should be considered in designing perches. Crossbars are not necessary; in fact, crossbars limit the directions the bird can face to best cope with wind. Extreme height is not necessary; Wakeley (1978b) found that ferruginous hawks used fence posts far more often than telephone poles in his study area, though his sample size was small.

Minimizing Direct Human Disturbance

Habitat protection is a key component of habitat management for sensitive wildlife species. That the ferruginous hawk is a sensitive species, particularly during the incubation period, is a controversial subject. The controversy stems from the experiences of some of the earlier researchers with the species (Weston 1968, Olendorff 1973, and others who chose not to take credit for causing desertions). Weston (1968) and Olendorff (1973) found that ferruginous hawks would desert their nests after a single visit during incubation, whereas other species (Swainson's hawks, prairie falcons [*Falco mexicanus*], great horned owls) would tolerate such disturbance. Whether the ferruginous hawk is sensitive is open for debate, but these early reports altered the research methods of many subsequent researchers to the point that ferruginous hawk nests are usually not entered during incubation today. Researchers are reluctant to take the chance and possibly cause nests to be abandoned.

White and Thurow (1979) speculated that low prey years could cause ferruginous hawks to be more prone to nest desertion. Based on observations in the Snake River Birds of Prey Area, M. N. Kochert (Bur. Land Manage., pers. commun.) speculated that ferruginous hawks nesting on transmission towers are protected by height and stability of the tower nests and are less likely to desert. These speculations, as well as the whole issue of ferruginous hawk sensitivity, remains an avenue for future research.

The fact remains, however, that the possible sensitive nature of ferruginous hawks requires that land managers, land owners, developers, and the general public be more aware of raptor habitats and the need of some species for space lacking human activity. Distance from human disturbance appears to be as important to ferruginous hawks as home range size or "nearest neighbor" distances.

The warnings of Fyfe and Olendorff (1976: 5) about what may happen if nesting raptors are disturbed are worthy of repetition here:

> "...1) the parent birds may become so disturbed that they desert their eggs or young completely; 2) the incidence of egg breakage or trampling of young by parent birds may be increased, as may the chances of cooling, overheating, loss of humidity, and avian predation of eggs; 3) newly hatched birds may be chilled or overheated, and may die in the absence of brooding; 4) older nestlings may leave the nest prematurely, damaging still-growing feathers and breaking bones at the end of futile first flights, or may be forced to spend one night or several on the ground where they may be highly vulnerable to predation; 5) mammalian predators may follow human scent trails directly to the eggs or young...."

Many of these effects require rather close approach to nests, but off-road vehicles provide easy access to even the most remote ferruginous hawk nests.

Thus, both general and site-specific habitat protection are needed. General approaches involve legislation, law enforcement, and development and implementation of land-use planning recommendations that protect ferruginous hawks and their habitats (e.g., land withdrawals and acquisitions, administrative closures, zoning, acquisition of conservation easements, and stipulation of protective buffer zones in land-use authorizations). Site-specific habitat protection recommendations to minimize human disturbance are listed below.

Management Recommendation No. 18. Post "No Trespassing" signs or wildlife alert (warning) signs at ferruginous hawk territories most vulnerable to human disturbance. Olendorff and Stoddart (1974) and Lokemoen and Duebbert (1976) have

shown the significance of remoteness to the success of nesting ferruginous hawks, be it provided by distance, intervening terrain, or limited access. Physical remoteness usually is not manageable, because of the permanent nature of roads and the ease of access provided by off-road vehicles. However, posting of signs, maintenance of signs, and patrol and enforcement during the nesting season can provide the potential for solitude and protection from disturbance that may result in an increase in ferruginous hawk nesting success. Ensign (1983) recommended that posting occur at a distance of 450 m from nests, the distance at which the hawks reacted (crouched) to approaches by people toward their nests. Patrols of private ranches, enforcement of restrictions, and expulsion of trespassers are particularly useful, provided ranch hands do not indiscriminately persecute raptors. Administrative closure of public land is a legal habitat protection measure available to Federal land managing agencies, but the time required to implement and enforce such a closure might be better spent on some other type of ferruginous hawk management.

Management Recommendation No. 19. **Where dense populations of ferruginous hawks are particularly susceptible to shooting, administratively close public land to firearms during the nesting season.** Firearms closures are within the authority of some Federal and state land and/or wildlife managing agencies. Such seasonal closures are in effect in various parts of the range of the California condor (*Gymnogyps californianus*; U.S. Fish and Wildl. Serv.), several osprey (*Pandion haliaetus*) management areas (U.S. For. Serv.), the Snake River Birds of Prey Natural Area in Idaho (U.S. Bur. Land Manage.), and Aravipa Canyon in Arizona (U.S. Bur. Land Manage.). In each case a severe shooting problem was recognized and resulted in firearms use restrictions. Generally, restrictions during the raptor nesting season do not interfere with scheduled fall hunting seasons.

Mitigation of Development Impacts

Urbanization and Cultivation. Urbanization and cultivation are so closely tied to meeting fundamental human needs for shelter and food that they result in inevitable, basically unmitigatable adverse impacts to ferruginous hawk habitats. Development of private lands is uncontrollable, except by local zoning ordinances which can be incredibly powerful tools for conservation. Thus, protection and management of ferruginous hawk habitat on Federal lands is of particular importance. Because many parts of the western United States are largely in public ownership administered by the Bureau of Land Management, such areas will remain pivotal to the survival of the ferruginous hawk.

Management Recommendation No. 20. **Maintain lands which have significant numbers of nesting ferruginous hawks in public ownership.** Land sales, desert land entries, land exchanges, and other land actions, where the ultimate use of the land could involve human habitation and/or agriculture, should be closely scrutinized for their effects on ferruginous hawk populations and habitats. Mitigations, such as land acquisitions, land exchanges where the government receives excellent ferruginous hawk habitat, establishment of ferruginous hawk management areas, and funding contributions for ferruginous hawk management and research, should be incorporated into the planning and negotiations involved with lands and realty actions important to the species.

Other Surface-disturbing Developments. Major development projects that can destroy ferruginous hawk habitats include construction of dams and reservoirs, mining (particularly coal mining; Platt 1984, 1985, 1986), and oil and gas development (Harmata 1991). Mining

is of particular concern because different aspects of mining and energy development--exploration, extraction, processing, and transportation (delivery)--have different, compounding impacts. However, whether the activity involves seismic blasting to find the resource, operation of heavy equipment to gather or process the ore, or haul road, pipeline, or power line construction to deliver the product, certain general habitat management recommendations are appropriate. These involve buffer zones--both spatial and temporal--as well as recommendations on how to minimize direct mortality of ferruginous hawks.

Management Recommendation No. 21. **Establish spatial buffer zones around occupied ferruginous hawk nests likely to be impacted by surface-disturbing developments.** Spatial buffer zones were defined by White and Thurow (1985: 21) as "...the minimum area around a nest that must be kept free of human intrusion to prevent harmful effects associated with disturbance."

Examples of spatial buffers for ferruginous hawks are as follows:

> **Brief disturbance** -- 250 meters (275 yards) from the nest (White and Thurow 1985).
> **Prolonged activity--** 800 meters (880 yards) line of sight of the nest.
> -- 400 meters (440 yards) to 800 meters (880 yards) from the nest with an intervening visual buffer

Buffer zones for prolonged activity (one-half hour to several days) should be evaluated on an individual basis; other (generally more restrictive) recommendations may be equally valid. For example, Suter and Joness (1980) recommended that intermittent activities should be kept at least 500 m from occupied nests or limited to a few minutes and periods of moderate temperature. Construction and similar noise, and extended activities, should be kept at least 1 km from nesting attempts to avoid nest abandonment (Suter and Joness 1980). All spatial buffer zones should be accompanied by temporal buffer zones. Quantification of human disturbance and refinement of buffer zone requirements is a recognized research need for all raptors (Suter and Joness 1980), not just ferruginous hawks.

Management Recommendation No. 22. **Establish temporal buffers during which land treatment or other development will be suspended or avoided so as to allow ferruginous hawks to initiate and complete breeding activities at a potentially impacted nest (Call 1979b).** For example, Ensign (1983) recommended restricted use of cattlemen's trails (small roads) from March to mid-July in his southeast Montana study area.

The nesting period for ferruginous hawks (laying to fledging) in the United States runs from about 18 March through 24 July (See Nesting Chronology, this paper). To accommodate nest site selection by most of the earlier nesters and dispersal by the latest birds to fledge, the temporal buffer for ferruginous hawks should be about 1 March through 1 August each year. Modification of the March date is very difficult because nest site selection is said to be one of the most critical periods of the nesting cycle (Olendorff 1971) and it is the least well known. Conservatism is in order. The 1 August date depends on the verified progress of the nesting attempt. By correctly aging young ferruginous hawks (Moritsch 1985) and adding 68 days to the hatching date, a safe date can be determined for the beginning or resumption of the planned development activity.

Management Recommendation No. 23. **In cases where development will surely cause abandonment by a pair of nesting hawks, transfer the eggs or nestlings to other ferruginous hawk nests as a last resort**

(Howard and Wolfe 1976). Proper permitting and coordination with state and Federal wildlife authorities is always necessary whenever nestlings are handled. Displaced ferruginous hawk eggs should be artificially incubated or placed temporarily into the nest of a surrogate species (e.g., another *Buteo*) until the foster parent ferruginous hawks have hatched their own young. Foster chicks should be as old or slightly older than the chicks in the nest they will be fostered into. The literature concerning fostering raptors, a proven conservation measure, has been reviewed by Olendorff et al. (1980).

Construction of Power Lines and Pipelines. Considerable numbers of ferruginous hawk nest sites are provided by power transmission towers and to a lesser extent by poles carrying electric distribution lines (Gilmer and Stewart 1983, Steenhof et al. 1993, Table 3 this paper). Ferruginous hawks are rarely electrocuted or killed by collisions with lines (Benson 1981, Olendorff et al. 1981). Thus, the tendency for the species to use transmission towers as perches and nest substrates is more a potential mitigation for other types of negative impacts than a problem for the industry.

Pipelines are sometimes marked with wooden poles 3 to 4 m high carrying signs identifying the pipeline company. Pipelines also traverse considerable remote ferruginous hawk habitat. These poles could easily be topped with artificial nesting structures for ferruginous hawks.

Management Recommendation No. 24. Encourage electric power companies to plan for and install artificial nest structures for ferruginous hawks on new electric transmission line towers. Artificial nesting platforms positioned on transmission towers during construction are known to attract nesting hawks and eagles. Hawks nesting on power line towers sometimes have a higher success rate than pairs nesting on natural substrates (Steenhof et al. 1993), but not always (Gilmer and Wiehe 1977). This management technique has the added benefit of attracting hawks and eagles to positions on the towers where they will not foul the lines with sticks and defecations.

Management Recommendation No. 25. Encourage pipeline companies to mark pipeline routes with ferruginous hawk nesting structures. If such markings are not used, encourage pipeline companies to install artificial nesting structures (whenever the construction equipment is in an appropriate area) as partial mitigation for other construction impacts.

Habitat Analysis

Management of ferruginous hawks and their habitats first requires 1 or more analyses of the area to be managed. This can involve the combined use of site-specific data (inventories, site records, museum records, etc.), the published literature, unpublished information, personal experience, new studies, and conceptual modeling, such as Wildlife Habitat Relationships analyses (Maser et al. 1979a) and Habitat Suitability Index Models (Jasikoff 1981). No simple technique is likely to yield the best management practices. In the following discussion, managers are introduced to relatively complex habitat analysis techniques that will facilitate decision-making or, ultimately, predict the results of management actions. Details about these techniques are available in accompanying references. The techniques may not work in all ferruginous hawk habitat, but can be used by biologists as a starting point.

Management Recommendation No. 26. Use habitat analysis techniques developed by Chris Maser (Bur. Land Manage.) and Jack Ward Thomas (U.S. For. Serv.) (Maser and Thomas 1983) to help land managers make

decisions on how to manage habitats for the ferruginous hawk. Using such an analysis, habitats can be managed for whichever animal is desired on a particular piece of land. The following is a brief introduction to this intriguing technique. Biologists will have to do much work to determine which species are present in the area, to categorize the various habitats present, to determine how the animals use the habitat, etc. However, once data are obtained, the types of analysis are extensive.

Wildlife Habitat Relationships involves aggregating animals into life forms based on their habitats and feeding strategies. For example, in southeastern Oregon the ferruginous hawk is a member of "life form 4" which is a group of animals that reproduces on cliffs, rims, and/or talus and feeds on the ground, primarily on species from "life form 5" (reproduces on ground, feeds on ground) and "life form 15" (reproduces underground, feeds on or underground; Maser et al. 1984).

In northwestern Oregon, southeastern Idaho, Utah, eastern Colorado, and North Dakota, where trees are the most frequently used nest substrate (Table 3), the ferruginous hawk would be classified in "life form 12." This distinction is important only to illustrate that outside of southeastern Oregon, analyses and management prescriptions using Wildlife Habitat Relationships can differ based on the life forms of the animals in that particular location.

Wildlife Habitat Relationships analysis (see Maser et al. 1984) is conducted by Levels. Level 1 is on a life form basis, and Level 2 analysis involves extraction of information concerning the "...relationship of individual species for feeding and reproduction to plant communities and plant community structural conditions" (Maser et al. 1984: 3). Level 3 analysis involves a 1-line summary of key information on each species (Maser et al. 1984), and Level 4 is a list of selected references for each species with which one can begin a literature review. For the ferruginous hawk, thorough information for Level 3 and 4 are represented by other sections of this paper, by the Literature Cited section, and by Appendix C, Other Ferruginous Hawk Literature.

The value of a Wildlife Habitat Relationship analysis is revealed by an example from Level 2. We find a close relationship between the reproductive and feeding orientations to plant communities of ferruginous hawks and the same orientations of its prey species (Table 8). Table 8 was reconstructed from Maser et al. (1984: Appendix 6) for the ferruginous hawk and the 12 prey species that occur in southeastern Oregon which also are represented by more than a trace (biomass basis) in the total diet of the ferruginous hawks (Appendix B).

The matrix (Table 8) resulting from this technique reveals that in 4 of the 7 plant communities where ferruginous hawks show a primary orientation for reproduction and feeding, large numbers of prey species occur with either primary reproduction and/or feeding orientations. These communities (low sagebrush/bunchgrass, black greasewood/grass, tall sagebrush/bunchgrass, and riparian) should be high priority for ferruginous hawk management in southeastern Oregon. Permanent wet meadows are important to many of the prey species, but are used only secondarily for feeding by the ferruginous hawk, and crested wheatgrass is of intermediate value to ferruginous hawks. Those communities which are of lesser value to ferruginous hawks or their prey would not be high in management priority.

The importance of shrub and grass components (as well as a tree component in

Table 8. Orientation of the ferruginous hawk and its principal prey species to the plant communities of southeastern Oregon (from Maser et al. 1984:Appendix 6).

●- Primary (≥ 40%) reproduction and feeding
R - Primary (≥ 40%) reproduction only
F - Primary (≥ 40%) feeding only

O- Secondary (≤ 40%) reproduction and feeding
r - Secondary (< 40%) reproduction only
f - Secondary (< 40%) feeding only

		crested wheatgrass (seeded)	subalpine bunchgrass	perm. wet meadows	seasonally wet meadows	shadscale saltbrush/bunchgr.	low sagebrush/bunchgrass	black greasewood/grass	tall sagebrush/bunchgrass	squaw apple/bunchgrass	curlleaf mountainmahogany/bunchgr.	curlleaf mountainmahogany/pinegr.	juniper/sagebrush/bunchgrass	curlleaf mountainmahogany/shrub	quaking aspen/grass	quaking aspen/mountain big sagebrush/bunchgrass	riparian	Number of plant communities used by each species	
																		R	F
Ferruginous Hawk		O		f	f	F	●	●	●	F	f	f	●	F	●	●	●	7	10
PREY SPECIES																			
Gopher snake				●	O	O	O	●	●	O	O	O	●	O	O	O	●	5	5
Ring-necked pheasant				f	f		f		●	f		f	f	f	f		●	2	2
Western meadowlark		F	f	F	F		●	O	●	●	O	O	●	O	●	●	F	6	10
Mountain cottontail						O	●	●	●	O	●	●	●	●			●	8	8
White-tailed jackrabbit		F	F	F	f				●	F	F	F	F	F			F	1	10
Black-tailed jackrabbit		F	F	F	F	F	●	F	●	F	F	F	F	F			F	2	14
Townsend's ground squirrel		●			●				●								●	4	4
Richardson's ground squirrel									●									1	1
Belding's ground squirrel			●	●	O		●		●								●	5	5
Townsend's pocket gopher		●		●	●	●	●	●	●								●	8	8
Northern pocket gopher		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	16	16
Ord's kangaroo rat		O				●		●	●									1	1
Number of species using each plant community	R	3	2	4	3	3	6	5	12	2	2	2	4	2	2	2	7		
	F	6	4	7	5	4	6	6	12	4	4	4	6	4	2	2	10		

juniper and riparian communities) to ferruginous hawks is also evident from this analysis. This is corroborated by an analysis of orientation to plant structure for the ferruginous hawk and its prey species (Table 9) as extracted from Maser et al. (1984: Appendix 7). Higher orientations of the prey species occur in low shrub, tall shrub, and tree/shrub conditions, and lower orientations in grass-forb and tree/grass conditions, particularly the latter. The ferruginous hawk feeds only secondarily in all of the bare ground conditions and would as a rule encounter only 3 of the prey species there (the gopher snake [*Pituophis catenifer*] and the 2 jackrabbits). Thus, bare ground is not a very important foraging habitat for most ferruginous hawks.

Although these orientations are important, they are not the sole determinants of habitat use by ferruginous hawks. According to Maser et al. (1984), the versatility score is a measure of combined reproduction and feeding orientations to both plant communities and plant structural

Table 9. Orientation of the ferruginous hawk and its principal prey species to the plant structural conditions of southeastern Oregon (from Maser et al. 1984:Appendix 7).

● - Primary (≥ 40%) reproduction and feeding
O - Secondary (≤ 40%) reproduction and feeding
R - Primary (> 40%) reproduction only
r - Secondary (< 40%) reproduction only
F - Primary (≥ 40%) feeding only
f - Secondary (< 40%) feeding only

		Structural Conditions																
		Grass-forb			Low Shrub			Tall Shrub			Tree			Tree/Shrub			No. of plant structures used by each species	
		bare ground	annuals	bunchgrass	bare ground	annuals	bunchgrass	bare ground	annuals	bunchgrass	bare ground	annuals	bunchgrass	bare ground	annuals	bunchgrass	R	F
Ferruginous Hawk		f	F	●	f	●	●	f	●	●	f	●	●	f	●	●	9	10
PREY SPECIES																		
Gopher snake			F	O	F	●	●	F	●	●		O	O		O	O	4	7
Ring-necked pheasant			●			●			●						●		4	4
Western meadowlark			●	●		F	F		F	F		F	F		F	F	2	10
Mountain cottontail						O	O		●	●		O	O			●	4	4
White-tailed jackrabbit			F	F		f	●		●	●	f	F	F	f	●	●	5	9
Black-tailed jackrabbit			F	F		f	●		●	●	f	F	F	f	●	●	5	9
Townsend's ground squirrel				●		O	●		O	O			●		O	●	4	4
Richardson's ground squirrel				O		●	●		O	O					O	O	2	2
Belding's ground squirrel			●	●		●	●		O	0							4	4
Townsend's pocket gopher			●	●		●	●		O	O		●	●		●	●	8	8
Northern pocket gopher			●	●		●	●		●	●		●	●		●	●	10	10
Ord's kangaroo rat			O	O		O	O		●	●		●	●		●	●	6	6
No. of species using each plant structure	R	0	5	5	0	6	8	0	7	6	0	3	4	0	6	7		
	F	0	8	7	1	7	9	1	8	7	0	6	7	0	7	8		

conditions. The versatility score of the ferruginous hawk is 36 (Maser et al. 1984: Appendix 11), higher than only 3 of the 30 other birds and mammals in life form 4, which as a life form has the highest mean versatility score (Maser et al. 1984: Appendix 12). Compared to the 20 other raptor species in southeastern Oregon, the ferruginous hawk is equal in versatility score to the red-tailed hawk and exceeded only by the turkey vulture (*Cathartes aura*), golden eagle, and great horned owl.

The high versatility of ferruginous hawks relative to plant communities and structural conditions is in large part a result of the species' use of diverse nest substrates in special geomorphic and artificial habitats (Table 3). For further clarification of the importance of these geomorphic and human-made habitats to

ferruginous hawks, review the pertinent portions of Maser et al. (1979a) and Maser et al. (1979b).

Tables 8 and 9 show that where the ferruginous hawk reproduces, it finds most of its prey: 1 species of cottontail, western meadowlark, 3 species of ground squirrels, 2 species of pocket gophers, and Ord's kangaroo rat (*Dipodomys ordii*). With regard to plant structure, most conditions present excellent food gathering potential, except bare ground where neither the prey nor the hawk are found very often (Table 9). If managers perpetuate the habitats where both prey and ferruginous hawks reproduce and feed primarily, they ultimately will benefit the hawk.

Management Recommendation No. 27. **Use the Habitat Suitability Index Model (Jasikoff 1981) to analyze the habitat of ferruginous hawks.** In response to demands for improved techniques for habitat analyses, environmental impact analysis, habitat protection, and habitat management the U.S. Fish and Wildlife Service, Habitat Evaluation Procedures Group, developed a Habitat Suitability Index (HSI) Model for ferruginous hawks (Jasikoff 1981). This model, intended to apply to the principal range of the species north of Arizona and New Mexico during the breeding season, considered the "quality of life requisites" relating to food, reproduction, and special habitat needs of ferruginous hawks. Food supply was further related to vegetation structure as with the Wildlife Habitat Relationships analysis of the Forest Service. Reproduction was considered dependent on nest site availability provided by trees, cliffs, and topographic relief. Special habitat needs included a low level of human disturbance and a relatively small amount of intensive agriculture.

The usefulness of the model's mathematically derived habitat needs is only as good as the accuracy of the data on which they are based. However, Jasikoff's (1981) analysis and identification of variables that should be considered in ferruginous hawk habitat management has merit. Application of the HSI Model to the ferruginous hawk is complicated by the relatively high versatility of the species. Jasikoff (1981) recognized that the ferruginous hawk is a "multicover type species." For each cover type the HSI Model requires information on area, average height of the vegetative canopy, percent vegetative canopy cover, topographic diversity, availability of cliffs or rock outcrops, distance to suitable nest trees, and level of human disturbance. Interspersion variables include the percent of each cover type optimal for food availability, percent of each cover type optimal for ferruginous hawk reproduction, and the distance between the various cover types. All 13 cover types listed by Jasikoff (1981) seem to have some value to ferruginous hawks for feeding and/or reproduction.

This complexity and the lack of field verification tests for the model make its application problematic. However, the HSI Model remains as an alternative or a complement to analyses using Wildlife Habitat Relationships.

RESEARCH NEEDS

Monitoring.

The most critical need for study of ferruginous hawks is a monitoring program that will assess long-term population trends over the species' entire range. Such a program would provide the necessary information to answer the question whether the species is threatened or endangered. In addition, it will simultaneously provide managers with much needed information to manage the species.

Long-term trend data are mostly lacking. Only 9 studies or pairs of studies in the United States span 6 years, or else involve the same

area more than 6 years apart (Fig. 8). (Studies presented in Fig. 8 are those with 7 years or more of data. The first year is omitted because of the tendency for researchers not to find all of the nests during their first year. Studies of the same area several years apart may include only 1 or 2 years of study at each end.) Fig. 8 reveals the dearth of substantial long-term data on the total population of ferruginous hawks in the United States.

The recommended monitoring approach is the type of monitoring done by Schmutz (1984, 1987b, 1993) and Banasch (1990) in Canada. They estimated ferruginous hawk nesting populations over a large area (Schmutz--Alberta; Banasch--much of the species range in Saskatchewan) from sampling randomly selected quadrats. Schmutz recommends monitoring every 5 years.

There would be several direct spinoffs from these data that could not be gained in any other way. Fluctuations in ferruginous hawk populations could be researched starting from a study of this type. Woffinden and Murphy (1989) speculated that the ferruginous hawk is somewhat nomadic from year to year, possibly taking advantage of prey cycles. The decline of Woffinden and Murphy's (1989) population in Utah and the doubling of populations in some years in other locations (Gilmer and Stewart [1983], Platt [1986], Woffinden and Murphy [1989], Jurs [U.S. Bur. Land Manage., pers. commun.]) seem to support this idea. The problem is that few studies occur long enough in a single place to answer the question of nomadism, or they do not involve a large enough area to pick up these changes in breeding populations.

Another spinoff from monitoring studies would be the assessment of nest substrate use. This paper analyzes nest substrate using existing data, but this technique is full of biases that could be eliminated by a large 1-year study involving many researchers in many areas. It is best to analyze nest substrate in a given year rather than to lump years together.

This type of study needs to be coordinated by a research center, such as the Raptor Research and Technical Assistance Center. Researchers must be found throughout the species' range, or technicians must be sent from a central location to all parts of the species' range. Such an approach would be expensive, but it would solve many problems relative to the ferruginous hawk.

Life History Studies.

Powers (1981) studied behavior of nesting birds, and Wakeley (1976, 1978a, 1978b) studied their hunting behavior. More study of hunting behavior, particularly elsewhere in the species' range or during the non-nesting season, would be useful. Studies of adult behavior, particularly breeding behavior early in the nesting season, is worthy of more study. This would answer the questions about non-laying pairs of ferruginous hawks which are not uncommon in the Snake River Birds of Prey Area (Kochert and Steenhof, U.S. Bur. Land Manage., pers. commun.).

Studies of Human Disturbance.

Because considerable controversy exists over the effects of research on the ferruginous hawk, more study is needed into this problem (Weston 1969, Olendorff 1973, Busch 1977, Busch et al. 1978, White and Thurow 1985). However, such studies must be well-designed. The real controversy is whether ferruginous hawks will desert their nests if disturbed during the incubation period. Factors such as food availability, accessibility of the nest (whether a ground nest or one high on a power pole), and the field techniques of the researchers are suspected of influencing whether the hawks desert their nests.

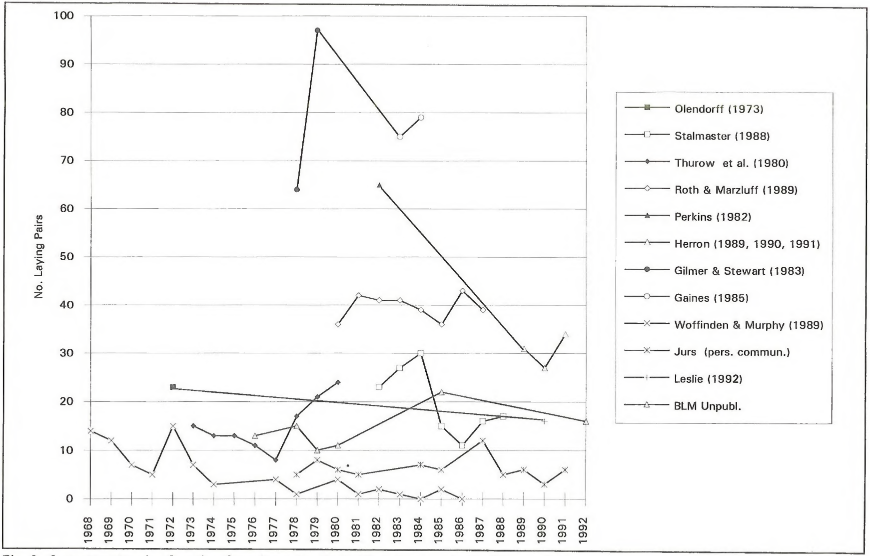

Fig. 8. Long-term trends of nesting ferruginous hawks in 12 study areas in the Western U.S.

LITERATURE CITED

Andersen, D. E., and O. J. Rongstad. 1989. Birds of prey on the Pinon Canyon Maneuver Site, Colorado. Wisconsin Coop. Wildl. Res. Unit, Madison. 67pp.

Anderson, W. C. 1974. Raptor management techniques in southeastern Colorado. Abstract only. Page 121 *in* F. N. Hamerstrom, Jr., B. E. Harrell, and R. R. Olendorff, eds. Management of raptors. Raptor Res. Rep. No. 2. Raptor Res. Found., Inc., Vermillion, S.D.

Anderson, W. C., and G. R. Craig. 1975. Raptor population and productivity studies in southeastern Colorado. Pages 153-164 *in* Colorado Div. Wildl., Game Res. Rep., January, 1975. Denver, Colo.

Anderson, W. C., and G. R. Craig. 1977. Raptor population and productivity studies in southeastern Colorado. Pages 207-211 *in* Colorado Div. Wildl., Game Res. Rep., January, 1977. Denver, Colo.

Anderson, W. C., and T. M. Follett. 1978. Nest-site management techniques for increasing productivity of grassland raptors. Paper presented at the 1978 Raptor Res. Found. Annu. Meeting, Allentown, Pa.

Baker, M. F., and N. C. Frischknecht. 1971. Relative abundance of mice on seeded sagebrush range in relation to grazing. U.S. Dep. Agric. For. Serv. Res. Note INT-147.

Banasch, U. 1990. Ferruginous hawk survey in southern Saskatchewan during 1988. Unpubl. Rep. Can. Wildl. Serv. Edmonton, Alta. 29pp.

Banasch, U. 1991. Ferruginous hawk nesting densities on Class I and II habitat in Saskatchewan. Pages 215-218 *in* G. L. Holroyd, G. Burns, and H. C. Smith, eds. Proc. second endangered species and prairie conservation workshop. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 15.

Bechard, M. J. 1981. Historical nest records for the ferruginous hawk in Manitoba. Can. Field-Nat. 95:467-469.

Bechard, M. J., K. D. Hague-Bechard, and D. H. Porter. 1986. Historical and current distributions of Swainson's and ferruginous hawks in southern Idaho. Unpubl. Rep. Boise State Univ., Boise, Id. 58pp.

Bechard, M. J., R. L. Knight, D. G. Smith, and R. E. Fitzner. 1990. Nest sites and habitats of sympatric hawks (*Buteo* spp.) in Washington. J. Field Ornithol. 61:159-170.

Beery, D. D. 1974. Ferruginous hawk in Washington: a nesting survey. Washington State Univ., Pullman. 23pp.

Bendire, C. E. 1892. Life histories of North American birds. Pages 259-262 *in* U.S. Nat. Mus. Spec. Bull. 1.

Benson, P. C. 1979. Land use and wildlife with emphasis on raptors. U.S. Dep. Agric. For. Serv., Intermountain Region, Lakewood, Colo. 32pp.

Benson, P. C. 1981. Large raptor electrocution and power pole utilization: a study in six western states. Ph.D. Diss. Brigham Young Univ., Provo, Ut. 98pp.

Bent, A. C. 1937. Life histories of North American birds of prey. Order Falconiformes. (Part 1). Smithsonian Institution, Washington, D.C. 409pp.

Black, A. 1992. Ferruginous hawk reproduction and habitat survey. Northern Rockies Conservation Cooperative. Jackson, Wyo. 30pp.

Black, H. L., and N. C. Frischknecht. 1971. Relative abundance of mice on seeded sagebrush-grass range in relation to grazing. U.S. Dep. Agric. For. Serv. Res. Note INT-147. 8pp.

Blair, C. L. 1978. Breeding biology and prey selection of ferruginous hawks in northwestern South Dakota. M.S. thesis. South Dakota State Univ., Brookings. 60pp.

Blair, C. L., and F. Schitoskey, Jr. 1982. Breeding biology and diet of the ferruginous hawk in South Dakota. Wilson Bull. 94:46-54.

Bohm, R. T. 1977. Artificial nest platforms for raptors. Raptor Res. 11:97-99.

Bolen, E. G. 1975. Eagles and sheep: a viewpoint. J. Range Manage. 28:11-17.

Borg, K., K. Erne, E. Hanko, and H. Wanntorp. 1970. Experimental secondary methyl mercury poisoning in the Goshawk (*Accipiter g. gentilis* L.). Environ. Pollut. 1:91-104.

Brown, L. H., and D. Amadon. 1968. Eagles, hawks, and falcons of the world. McGraw-Hill Book Co., New York, N.Y. 945pp.

Busch, D. E. 1977. Fluctuations in metabolism as indicated by heart rate in buteo hawks. M.S. thesis. Univ. Nebraska, Omaha. 45pp.

Busch, D. E., W. A. Degraw, and N. C. Clampitt. 1978. Effects of handling-disturbance stress on heart rate in the ferruginous hawk (*Buteo regalis*). Raptor Res. 12:122-125.

Buttery, R. F., and P. W. Shields. 1975. Range management practices and bird habitat values. Pages 183-184 *in* D. R. Smith, ed. Proc. symposium on management of forest and range habitats for nongame birds. U.S. For. Serv., Washington, D.C.

Call, M. W. 1976. Raptor survey in the Rawlins and Rock Springs Districts, Wyoming. Unpubl. Rep. U.S. Bur. Land Manage., Denver, Colo. 45pp.

Call, M. W. 1979a. Nesting habitats and general status of the ferruginous hawk. Unpubl. Rep. U.S. Bur. Land Manage., Denver, Colo. 6pp.

Call, M. W. 1979b. Habitat management guides for birds of prey. U.S. Bur. Land Manage. Tech. Note T/N-338. Denver, Colo. 70pp.

Call, M. W. 1985. Status of the ferruginous hawk in the western United States and Canada. Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif. 8pp.

Call, M. W. 1988. Ferruginous hawk monitoring and construction of artificial nests in the Shamrock Hills of Carbon County, Wyoming. Prepared for Energy International, Inc., Pittsburgh, Pa. 94pp.

Call, M. W. 1989. Raptor monitoring in the Shamrock Hills: a 1989 monitoring study. Prepared for Energy International, Inc., Pittsburgh, Pa. 111pp.

Call, M. W., and J. R. Tigner. 1991. Artificial nesting structures for ferruginous hawks (*Buteo regalis*) in Wyoming. Paper presented at the 1991 Raptor Res. Found. Annu. Meeting, Tulsa, Okla. 8pp.

Cameron, E. S. 1914. Ferruginous rough-leg, *Archibuteo ferrugineus* in Montana. Auk 31:158-167.

Chesser, R. K. 1979. Opportunistic feeding on man-killed prey by ferruginous hawks. Wilson Bull. 91:330-331.

Christensen, R. C. 1972. Raptor predation on pocket gopher populations by the use of hunting perches. M.S. thesis. Brigham Young Univ., Provo, Ut. 87pp.

Cottrell, M. J. 1981. Resource partitioning and reproductive success of three species of hawks (*Buteo* spp.) in an Oregon prairie. M.S. thesis. Oregon State Univ., Corvallis. 71pp.

Craig, G. R., and W. C. Anderson. 1979. Ferruginous hawk nesting studies. Pages 111-120 *in* Colorado Div. Wildl., Game Res. Rep., January, 1979. Denver, Colo.

Craig, T. H. 1979. Raptors of the Idaho National Engineering Laboratory Site. Idaho Oper. Office, Radiology and Environ. Sci. Lab. IDO-12089. Idaho Falls, Id. 27pp.

Cully, J. F., Jr. 1988. Gunnison's prairie dog: an important autumn raptor prey species in northern New Mexico. Pages 260-264 *in* Proc. southwest raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Cully, J. F., Jr. 1991. Response of raptors to reduction of a Gunnison's prairie dog population by plague. Am. Midl. Nat. 125:140-149.

Davy, G. L. 1930. Nesting of the ferruginous roughleg hawk in northern North Dakota. Oologist 47:14-18.

Dealy, J. E., D. A. Leckenby, and D. M. Concannon. 1981. Wildlife habitats in managed rangeland--the Great Basin of southeastern Oregon: plant communities and their importance to wildlife. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-120, Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 66pp.

De Smet, K. D., and M. P. Conrad. 1991. Status, habitat requirements, and adaptations of ferruginous hawks in Manitoba. Pages 219-221 *in* G. L. Holroyd, G. Burns, and H. C. Smith, eds. Proc. second endangered species and prairie conservation workshop. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 15.

Diller, L. V., and D. R. Johnson. 1982. Ecology of reptiles in the Snake River Birds of Prey Area. U.S. Bur. Land Manage. Boise, Id. 107pp.

Dunning, J. B., Jr. 1993. CRC handbook of avian body masses. CRC Press, Ann Arbor, Mich. 371pp.

Ellis, D. H., D. G. Smith, and J. R. Murphy. 1969. Studies on raptor mortality in western Utah. Great Basin Nat. 29:165-167.

Ensign, J. T. 1983. Nest site selection, productivity, and food habits of ferruginous hawk in southeastern Montana. M.S. Thesis. Montana State Univ., Bozeman. 83pp.

Evans, D. L. 1980. Impacts of surface mining on ferruginous hawks: recommendations for monitoring and mitigation. U.S. Fish and Wildl. Serv., Northern Prairie Wildl. Res. Cen., Jamestown, N.D. 39pp.

Evans, D. L. 1982. Status reports on twelve raptors. Special Scientific Report--Wildlife No. 238. U.S. Fish and Wildl. Serv., Washington, D.C. 70pp.

Farrell, J. P. 1987. Shamrock Hills raptor conservation area: 1987 inventory results. U.S. Bur. Land Manage., Divide Resource Area, Rawlins, Wyo. 19pp.

Fitzner, R. E., D. Berry, L. L. Boyd, and C. A. Rieck. 1977. Nesting of ferruginous hawks (*Buteo regalis*) in Washington 1974-75. Condor 79:245-249.

Flinders, J. T., and R. M. Hansen. 1975. Spring population responses of cottontails and jackrabbits to cattle grazing on shortgrass prairie. J. Range Manage. 28:290-293.

Fyfe, R. W., and H. I. Armbruster. 1977. Raptor research and management in Canada. Pages 282-293 *in* R. D. Chancellor, ed. World Conf. on Birds of Prey, Rep. of Proceedings. Int. Counc. Bird Preservation. Vienna, Austria.

Fyfe, R. W., and R. R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Serv. Occas. Pap. 23:1-17.

Gaines, R. C. 1985. Nest site selection, habitat utilization, and breeding biology of the ferruginous hawk in central North Dakota. M.S. thesis. North Dakota State Univ., Fargo. 32pp.

Gilmer, D. S., D. L. Evans, P. M. Konrad, R. E. Stewart. 1985. Recoveries of ferruginous hawks banded in south-central North Dakota. J. Field Ornithol. 56:184-187.

Gilmer, D. S., and R. E. Stewart. 1983. Ferruginous hawk populations and habitat use in North Dakota. J. Wildl. Manage. 47:146-157.

Gilmer, D. S., and J. M. Wiehe. 1977. Nesting by ferruginous hawks and other raptors on high voltage powerline towers. Prairie Nat. 9:1-10.

Hall, R. S., R. L. Glinski. D. H. Ellis, J. M. Ramakka, and D. L. Base. 1988. Ferruginous hawk. Pages 111-118 *in* Proc. southwest raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Harlow, D. L., and P. H. Bloom. 1989. Buteos and the golden eagle. Pages 102-110 *in* Proc. western raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Harmata, A. R. 1981. Recoveries of ferruginous hawks banded in Colorado. North Am. Bird Bander 6:144-147.

Harmata, A. R. 1991. Impacts of oil and gas development on raptors associated with Kevin Rim, Montana. Unpubl. Rep. Montana State Univ., Bozeman. 97pp.

Henjum, M. 1987. Inventory of nesting raptors in Union and Baker Counties, Oregon. Oregon Birds 13:151-156.

Herbert, L. 1987. Status of the ferruginous hawk in Finney County, Kansas. Typewritten report. Trenton, Mo. 4pp.

Herron, G. B. 1989. Population surveys, species distribution, and key habitats of selected nongame species. Nevada Dep. Wildl., Reno. Page 3.

Herron, G. B. 1990. Population surveys, species distribution, and key habitats of selected nongame species. Nevada Dep. Wildl., Reno. Page 5.

Herron, G. B. 1991. Population surveys, species distribution, and key habitats of selected nongame species. Nevada Dep. Wildl., Reno. Pages 2-7.

Houston, C. S. 1982. Artificial nesting platforms for ferruginous hawks. Blue Jay 40:208-213.

Houston, C. S. 1985. Ferruginous hawk nest platforms--progress report. Blue Jay 43:243-246.

Houston, C. S. 1991. Ferruginous hawk nesting success: a 19-year study. Page 222 *in* G. L. Holroyd, G. Burns, and H. C. Smith, eds. Proc. second endangered species and prairie conservation workshop. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 15.

Houston, C. S., and M. Bechard. 1984. Decline of the ferruginous hawk in Saskatchewan. Am. Birds 38:166-170.

Howard, R. P. 1975. Breeding ecology of the ferruginous hawk in northern Utah and southern Idaho. M.S. thesis. Utah State Univ., Logan. 59pp.

Howard, R. P., and M. Hilliard. 1980. Artificial nest structures and grassland raptors. Raptor Res. 14:41-45.

Howard, R. P., and M. L. Wolfe. 1976. Range improvement practices and ferruginous hawks. J. Range Manage. 29:33-37.

Howard, R., and L. Powers. 1973. Hawk of the desert. Anim. Kingdom 73:22-27.

Janes, S. W. 1985. Behavioral interactions and habitat relations among grassland and shrubsteppe raptors. Ph.D. Diss. Univ. Calif., Los Angeles. 218pp.

Jasikoff, T. M. 1981. Habitat suitability index model for the ferruginous hawk. Unpubl. Rep. U.S. Fish and Wildl. Serv., Biol. Serv. Program, Ft. Collins, Colo. 26pp.

Johnson, D., and J. H. Enderson. 1972. Roadside raptor census in Colorado--winter 1971-72. Wilson Bull. 84:489-490.

Kantrud, H. A., and R. L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. U.S. Fish and Wildl. Serv., Wildl. Res. Rep. 15. Washington, D.C. 33pp.

Kindschy, R. R. 1978. Rangeland management practices and bird habitat values. Pages 66-69 *in* R. M. DeGraaf, ed. Proc. workshop on nongame habitat management in the coniferous forests of the western United States. U.S. Dep. Agric. For. Serv,, Portland, Oreg.

Knight, R. L., and D. G. Smith. 1982. Summer raptor populations of a Washington coulee. Northwest Sci. 56:303-309.

Kochert, M. N. 1989. Responses of raptors to livestock grazing in the western United States. Pages 194-203 *in* Proc. western raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Kochert, M. N., B. A. Millsap, and K. Steenhof. 1988. Effects of livestock grazing on raptors with emphasis on the southwest. Pages 325-334 *in* Proc. southwest raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Konrad, P. M., and D. S. Gilmer. 1986. Post fledging behavior of ferruginous hawks in North Dakota. Raptor Res. 20:35-39.

Kuchler, A. W. 1964. Potential natural vegetation of the conterminous United States, manual to accompany the map. Am. Geogr. Soc. Spec. Publ. No. 36. 116pp.

Lardy, M. E. 1980. Raptor inventory and ferruginous hawk biology in southeastern Oregon. M.S. thesis. Univ. Idaho, Moscow. 52pp.

LeFranc, M. N., and R. L. Glinski. 1988. Southwest raptor management issues and recommendations. Pages 375-392 *in* Proc. southwest raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Leslie, D. G. 1990. Effect of long-term landscape changes on the birds of prey of the Pawnee National Grassland. Unpubl. Rep. Colo. Div. Wildl., Fort Collins. 6pp.

Leslie, D. G. 1992. Population status, habitat and nest-site characteristics of a raptor community in eastern Colorado. M.S. thesis. Colorado State Univ., Fort Collins. 45pp.

Lockhart, J. M. 1979. Status of nesting peregrine falcons and other selected raptor species in the Black Butte mine lease and adjacent lands. Pages 257-287 *in* Annu. Prog. Reports--1979, Denver Wildl. Res. Cent. U.S. Fish and Wildl. Serv., Denver, Colo.

Lockhart, J. M., D. W. Heath, and C. L. Belitsky. 1980. Status of nesting peregrine falcons and other selected raptor species on the Black Butte Mine lease and adjacent lands. Unpubl. Rep. U.S. Fish and Wildl. Serv., Wildl. Res. Cent., Sheridan Field Station. Sheridan, Wyo. 59pp. plus maps.

Lokemoen, J. T., and H. F. Duebbert. 1976. Ferruginous hawk nesting ecology and raptor populations in northern South Dakota. Condor 78:464-470.

MacLaren, P. A. 1986. Resource partitioning in an assemblage of breeding raptors from southeastern Wyoming. M.S. thesis. Univ. Wyoming, Laramie. 64pp.

Maser, C., J. M. Geist, D. M. Concannon, R. Anderson, and B. Lovell. 1979a. Wildlife habitats in managed rangelands--the Great Basin of southeastern Oregon: geomorphic and edaphic habitats. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-99, Pac. Northwest For. Range Exp. Stn., Portland, Oreg. 84pp.

Maser, C., and J. W. Thomas. 1983. Wildlife habitats in managed rangelands--the Great Basin of southeastern Oregon: introduction. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-160, Pac. Northwest For. Range Exp. Stn., Portland, Oreg. 15pp.

Maser, C., J. W. Thomas, and R. G. Anderson. 1984. Wildlife habitats in managed rangelands--the Great Basin of southeastern Oregon: the relationship of terrestrial vertebrates to plant communities and structural conditions. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-172, Pac. Northwest For. Range Exp. Stn., Portland, Oreg. 237pp.

Maser, C., J. W. Thomas, I. D. Luman, and R. Anderson. 1979b. Wildlife habitats in managed rangeland--the Great Basin of southeastern Oregon: manmade habitats. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-86, Pac. Northwest For. Range Exp. Stn., Portland, Oreg. 40pp.

Mathisen, J. E., and A. Mathisen. 1968. Species and abundance of diurnal raptors in the panhandle of Nebraska. Wilson Bull. 80:479-486.

McAnnis, D. M. 1990. Home range, activity budgets, and habitat use of ferruginous hawks (*Buteo regalis*) breeding in southwest Idaho. M.S. thesis. Boise State Univ., Boise, Id. 81pp.

Meyers, L. H. 1987. Nesting ecology of ferruginous hawks in S.W. Montana. Paper presented at the Montana Nongame Symposium, February 11, 1987. Kalispell, Mont. 14pp.

Monson, G. 1941. Effect of revegetation on the small bird population in Arizona. J. Wildl. Manage. 5:395-397.

Moore, D. A. 1987. Ferruginous hawk in Alberta. Pages 193-197 *in* G. L. Holroyd, W. B. McGillivray, P. H. R. Stepney, D. M. Ealey, G. C. Trottier, and K. E. Eberhart, eds. Proc. workshop on endangered species in the prairie provinces. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 9.

Moritsch, M. Q. 1985. Photographic guide for aging nestling ferruginous hawks. U.S. Bur. Land Manage. Boise, Id. 19pp.

Murie, O. J. 1934. Magpies and ferruginous rough-leg feeding together. Condor 36:114.

Murphy, J. R. 1978. Management considerations for some western hawks. Trans. North Am. Wildl. Nat. Resour. Conf. 43:241-251.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, S.D. 399pp.

Nydegger, N. C., and G. W. Smith. 1986. Prey populations in relation to *Artemisia* vegetation types in southwestern Idaho. Pages 152-156 *in* E. D. McArthur and B. L. Welch, eds. Proc. of a symposium on the biology of *Artemisia* and *Chrysothamnus*. U.S. Dep. Agric. U.S. For. Serv. Intermountain Res. Stn., Ogden, Ut. 398pp.

Oakleaf, R. J. 1976. Evaluation of land use practices affecting nongame. Unpubl. Rep. Nev. Dep. Fish and Game, Reno. 12pp.

Oakleaf, R. J. 1985. Ferruginous hawk: Wyoming. Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif. 7pp.

Olendorff, R. R. 1971. Falconiform reproduction: a review. Part 1. The pre-nestling period. Raptor Res. Rep. No. 1. Raptor Res. Found., Inc., Vermillion, S.D. 111pp.

Olendorff, R. R. 1973. Ecology of the nesting birds of prey of northeastern Colorado. U.S. Int. Biol. Prog., Grassland Biome, Fort Collins, Colo. Tech. Rep. No. 211. 233pp.

Olendorff, R. R. 1975. Population status of large raptors in northeastern Colorado. Pages 185-205 *in* J.R. Murphy, C.M. White, and B.E. Harrell, eds. Population status of raptors. Raptor Res. Rep. No. 3. Raptor Res. Found., Inc., Vermillion, S.D.

Olendorff, R. R., D. D. Bibles, M. T. Dean, J. R. Haugh, and M. N. Kochert. 1989. Raptor habitat management under the U.S. Bureau of Land Management multiple-use mandate. Raptor Res. Rep. No. 8. Raptor Res. Found., Inc., York, Pa. 80pp.

Olendorff, R. R., A. D. Miller, and R. N. Lehman. 1981. Suggested practices for raptor protection on power lines--the state of the art in 1981. Raptor Res. Rep. No. 4. Raptor Res. Found., Inc., St. Paul, Minn. 111pp.

Olendorff, R. R., R. S. Motroni, and M. W. Call. 1980. Raptor management--the state of the art in 1980. U.S. Bur. Land Manage. Tech. Note 345. 56pp.

Olendorff, R. R., and J. W. Stoddart, Jr. 1974. Potential for management of raptor populations in western grasslands. Pages 47-88 *in* F. N. Hamerstrom, Jr., B. E. Harrell, and R. R. Olendorff, eds. Management of raptors. Raptor Res. Rep. No. 2. Raptor Res. Found., Inc., Vermillion, S.D.

Owens, R. A., and M. T. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Can. J. Zool. 51:697-713.

Peacock, E. 1980. Powerline electrocution of raptors. Pages 2-5 *in* R. P. Howard and J. F. Gore, eds. Proc. workshop on raptors and energy developments. Idaho Chap., The Wildl. Soc., Boise, Id.

Perkins, M. W. 1982. Tree-nesting raptors in Nevada. North Am. Bird Bander 7:105-106.

Perkins, M. W., and W. J. Lindsey. 1983. Nesting studies of ferruginous hawks in the Ely BLM District, Nevada. North Am. Bird Bander 8:106-107.

Phillips, P. 1939. Distribution of rodents in overgrazed and normal grasslands of central Oklahoma. Ecology 17:673-679.

Phillips, R. L., and A. E. Beske. 1990. Distribution and abundance of golden eagles and other raptors in Campbell and Converse Counties, Wyoming. U.S. Fish and Wildl. Serv. Fish and Wildl. Tech. Rep. 27. Washington, D.C. 31pp.

Platt, S. W. 1984. Energy development and raptor populations on and adjacent to the Black Butte Coal Co. mine permit area. An interim progress report for field years 1981-1983. Black Butte Coal Co., Point of Rocks, Wyo. 62pp. plus maps.

Platt, S. W. 1985. Energy development and raptor populations on and adjacent to the Black Butte Coal Co. mine permit area. An interim progress report for field year 1984. Black Butte Coal Co., Point of Rocks, Wyo. 62pp. plus maps.

Platt, S. W. 1986. Energy development and raptor populations on and adjacent to the Black Butte Coal Co. Mine permit area. An interim progress report for field year 1985. Black Butte Coal Co., Point of Rocks, Wyo. 84pp. plus maps.

Powers, L. R. 1981. Nesting behavior of the ferruginous hawk (*Buteo regalis*). Ph.D. Diss. Idaho State Univ., Pocatello. 312pp.

Powers, L. R., and T. H. Craig. 1976. Status of nesting ferruginous hawks in the Little Lost River Valley and vicinity, southeastern Idaho. Murrelet 57:46-47.

Powers, L. R., R. (P.) Howard, and C. H. Trost. 1975. Population status of the ferruginous hawk in southeastern Idaho and northern Utah. Pages 153-157 *in* J. R. Murphy, C. M. White, and B. E. Harrell, eds. Population status of raptors. Raptor Res. Rep. No. 3. Raptor Res. Found., Inc., Vermillion, S.D.

Ratcliffe, B. D., and J. L. Murray. 1984. Recent successful nesting of ferruginous hawk in Manitoba. Blue Jay 42:215-218.

Restani, M. 1991. Resource partitioning among three Buteo species in the Centennial Valley, Montana. Condor 93:1007-1010.

Reynolds, H. G. 1958. Ecology of the Merriam kangaroo rat (*Dipodomys merriami* Mearns) on the grazing lands of southern Arizona. Ecol. Monogr. 28:111-127.

Reynolds, T. D., and C. D. Trost. 1981. Grazing, crested wheatgrass, and bird populations in southeastern Idaho. Northwest Sci. 55:225-234.

Rolfe, E. S. 1896. Nesting of the ferruginous rough-leg. Osprey 1:8-10.

Roth, S. D., Jr., and J. M. Marzluff. 1984. Nest location and its effect on success of ferruginous hawks in northwestern Kansas. Paper presented at the 1984 Am. Ornithologists' Union, Lawrence, Kans. 24pp.

Roth, S. D., Jr., and J. M. Marzluff. 1989. Nest placement and productivity of ferruginous hawks in western Kansas. Trans. Kans. Acad. Sci. 92:132-148.

Ryder, R. A. 1969. Diurnal raptors on the Pawnee Site. U.S. Biol. Prog., Grassland Biome, Fort Collins, Colo. Tech. Rep. No. 26. 16pp.

Salt, W. R. 1939. Notes on recoveries of banded ferruginous rough-legged hawks (*Buteo regalis*). Bird-Banding 10:80-84.

Schmutz, J. K. 1977. Relationship between three species of the genus *Buteo* (Aves) coexisting in the prairie-parkland ecotone of southeastern Alberta. M.S. thesis. Univ. Alberta, Calgary. 126pp.

Schmutz, J. K. 1983. Artificial nests for ferruginous hawks in southeastern Alberta. Unpubl. Rep. Arctic Inst. North Am., Univ. Calgary, Alta. 31pp.

Schmutz, J. K. 1984. Ferruginous hawk and Swainson's hawk abundance and distribution in relation to land use in southeastern Alberta. J. Wildl. Manage. 48:1180-1187.

Schmutz, J. K. 1987a. Effect of agriculture on ferruginous and Swainson's hawks. J. Range Manage. 40:438-440.

Schmutz, J. K. 1987b. Estimate of population size and probable causes of population stability in ferruginous hawks in southeastern Alberta. Unpubl. Rep. Univ. Saskatchewan, Saskatoon. 45pp.

Schmutz, J. K. 1987c. Factors limiting the size of the breeding population of ferruginous hawks. Pages 189-191 *in* G. L. Holroyd, W. B. McGillivray, P. H. R. Stepney, D. M. Ealey, G. C. Trottier, and K. E. Eberhart, eds. Proc. workshop on endangered species in the prairie provinces. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 9.

Schmutz, J. K. 1987d. Ferruginous hawk. Discussion and action list. Page 207 *in* G. L. Holroyd, W. B. McGillivray, P. H. R. Stepney, D. M. Ealey, G. C. Trottier, and K. E. Eberhart, eds. Proc. workshop on endangered species in the prairie provinces. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 9.

Schmutz, J. K. 1987e. Population size, distribution and survival of ferruginous hawks in N.W. Texas. Unpubl. Rep. Univ. Saskatchewan, Saskatoon. 36pp.

Schmutz, J. K. 1989a. Hawk occupancy of disturbed grasslands in relation to models of habitat selection. Condor 91:362-371.

Schmutz, J. K. 1989b. Management Plan for the ferruginous hawk in Canada. Unpubl. Rep. Univ. Saskatchewan, Saskatoon. 43pp.

Schmutz, J. K. 1991. Population dynamics of ferruginous hawks in Alberta. Pages 212-214 *in* G. L. Holroyd, G. Burns, and H. C. Smith, eds. Proc. second endangered species and prairie conservation workshop. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 15.

Schmutz, J. K. 1993. Population trends of ferruginous hawks in Alberta, including a synthesis for prairie Canada. Univ. of Saskatchewan, Saskatoon. 21pp.

Schmutz, J. K., and R. W. Fyfe. 1987. Migration and mortality of Alberta ferruginous hawks. Condor 89:169-174.

Schmutz, J. K., R. W. Fyfe, D. A. Moore, and A. R. Smith. 1984. Artificial nests for ferruginous and Swainson's hawks. J. Wildl. Manage. 48:1009-1013.

Schmutz, J. K., and D. J. Hungle. 1989. Population of ferruginous and Swainson's hawks increase in synchrony with ground squirrels. Can. J. Zool. 67:2596-2601.

Schmutz, J. K., K. A. Rose, and R. G. Johnson. 1989. Hazards to raptors from strychnine poisoned ground squirrels. J. Raptor Res. 23:147-151.

Schmutz, J. K., and S. M. Schmutz. 1980. Status of the ferruginous Hawk (*Buteo regalis*). Prepared for the Committee for Endangered Wildlife in Canada. Unpubl. Rep. Queens Univ., Kingston, Ontario. 25pp.

Schmutz, J. K., S. M. Schmutz, and D. A. Boag. 1980. Coexistence of three species of hawks (*Buteo* spp.) in the prairie-parkland ecotone. Can. J. Zool. 58:1075-1089.

Schmutz, J. K., W. D. Wishart, J. Allen, R. Bjorge, and D. A. Moore. 1988. Dual use of nest platforms by hawks and Canada geese. Wildl. Soc. Bull. 16:141-145.

Schmutz, S. M., and J. K. Schmutz. 1981. Inheritance of color phases of ferruginous hawks. Condor 83:187-189.

Smith, A. R. 1987. Status of the ferruginous hawk in Saskatchewan. Pages 199-203 *in* G. L. Holroyd, W. B. McGillivray, P. H. R. Stepney, D. M. Ealey, G. C. Trottier, and K. E. Eberhart, eds. Proc. workshop on endangered species in the prairie provinces. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 9.

Smith, D. G., and J. R. Murphy. 1973. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young Univ. Sci. Bull., Biol. Ser. 13:1-76. Provo, Ut.

Smith, D. G., and J. R. Murphy. 1978. Biology of the ferruginous hawk in central Utah. Sociobiology 3:79-98.

Smith, D. G., and J. R. Murphy. 1979. Breeding responses of raptors to jackrabbit density in the eastern Great Basin desert of Utah. Raptor Res. 13:1-14.

Smith, D. G., and J. R. Murphy. 1982. Nest site selection in raptor communities of the eastern Great Basin. Great Basin Nat. 42:395-404.

Smith, D. G., J. R. Murphy, and N. D. Woffinden. 1981. Relationships between jackrabbit abundance and ferruginous hawk reproduction. Condor 83:52-56.

Smith, G. W., and D. R. Johnson. 1985. Demography of Townsend ground squirrel population in southwestern Idaho. Ecology 66:171-178.

Snow, C. 1974. Ferruginous hawk (*Buteo regalis*). U.S. Bur. Land Manage. Tech. Rep. No. T/N-255. Denver, Colo. 23pp.

Stahlecker, D. W., and T. E. Behlke. 1974. Winter diurnal raptor populations of three habitat types in northeastern Colo. Colo. Field Ornithol. 20:6-17.

Stalmaster, M. V. 1981. Ferruginous hawk nesting mitigation, Bonanza Power Plant Project, Rio Blanco County, Colo. ERO Resources Corp., Golden, Colo. 11pp. and 3 maps.

Stalmaster, M. V. 1982. Ferruginous hawk nesting mitigation study: 1982--Deseret Western Railway Project. ERO Resources Corp., Golden, Colo. 60pp. and 4 maps.

Stalmaster, M. V. 1983. Ferruginous hawk nesting mitigation study: 1983. ERO Resources Corp., Golden, Colo. 78pp. and 4 maps.

Stalmaster, M. V. 1984. Ferruginous hawk nesting mitigation study: 1984. ERO Resources Corp., Golden, Colo. 83pp. and maps.

Stalmaster, M. V. 1988. Ferruginous hawk nesting mitigation study: final report. Rio Blanco and Moffat Counties, Colorado, Uintah County, Utah. Prepared for Western Fuels-Utah, Inc. ERO Resources Corp., Denver, Colo. 97pp.

Steenhof, K. 1983. Prey weights for computing percent biomass in raptor diets. Raptor Res. 17:15-27.

Steenhof, K. 1984. Use of an interspecific communal roost by wintering ferruginous hawks. Wilson Bull. 96:137-138.

Steenhof, K. 1987. Assessing raptor reproductive success and productivity. Pages 157-170 *in* B. A. Giron Pendleton, B. A. Millsap, K. W. Kline, and D. M. Bird, eds. Raptor management techniques manual. Natl. Wildl. Fed., Washington, D.C.

Steenhof, K., and M. N. Kochert. 1985. Dietary shifts of sympatric buteos during a prey decline. Oecologia 66:6-16.

Steenhof, K., M. N. Kochert, and J. A. Roppe. 1993. Nesting by raptors and ravens on electrical transmission line towers. J. Wildl. Manage. 57:271-281.

Stendell, R. C., D. S. Gilmer, N. A. Coon, and D. M. Swineford. 1988. Organochlorine and mercury residues in Swainson's and ferruginous hawk eggs collected in North and South Dakota, 1974-79. Environ. Monit. and Assessment 10:37-41.

Stewart, R. E. 1975. Breeding birds of North Dakota. U.S. Fish and Wildl. Serv., Northern Prairie Wildl. Res. Cent., Jamestown, N.D.

Suter, G. W., II., and J. L. Joness. 1980. Criteria for golden eagle, ferruginous hawk, and prairie falcon nest site protection. Raptor Res. 15:12-18.

Thurow, T. L., and C. M. White. 1983. Nest site relationship between ferruginous hawk and Swainson's hawk. J. Field Ornithol. 54:401-406.

Thurow, T. L., C. M. White, R. P. Howard, and J. F. Sullivan. 1980. Raptor ecology of Raft River Valley, Idaho. EG&G Idaho, Inc., Idaho Falls. 45pp.

Tigner, B. 1989a. Raptor monitoring in the Shamrock Hills, Carbon County, Wyoming, in 1989. Unpubl. Rep. U.S. Bur. Land Manage. Rawlins, Wyo. 5pp.

Tigner, B. 1989b. Productivity of ferruginous hawk artificial nest structures in the Great Divide Resource Area in 1988 and 1989. Unpubl. Rep. U.S. Bur. Land Manage. Rawlins, Wyo. 2pp.

Tomback, D. F., and J. R. Murphy. 1981. Food deprivation and temperature regulation in nestling ferruginous hawks. Wilson Bull. 93:92-97.

Ure, J., P. Briggs, and S. W. Hoffman. 1991. Petition to list as endangered the ferruginous hawk (*Buteo regalis*), as provided by the Endangered Species Act of 1973, as amended in 1982. Ferruginous Hawk Project, Salt Lake City, Ut. 9pp.

U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; Notice of finding on petition to list the ferruginous hawk. Federal Register 57(161):37507-37513.

Wadell, B., and C. Yde. 1979. Wildlife inventories within the Hanna Basin and Red Rim/China Butte KRCRA's. Unpubl. Rep. U.S. Bur. Land Manage. Rawlins, Wyo. 47pp.

Wagner, P. W. 1980. Raptor habitat relationships. Unpubl. Rep. Utah Div. Wildl. Resour., Salt Lake City. 28pp.

Wakeley, J. S. 1976. Food searching behavior of free-living ferruginous hawks: factors affecting the use of hunting methods and hunting sites. Ph.D. Diss. Utah State Univ., Logan. 73pp.

Wakeley, J. S. 1978a. Factors affecting the use of hunting sites by ferruginous hawks. Condor 80:316-326.

Wakeley, J. S. 1978b. Hunting methods and factors affecting use by ferruginous hawks. Condor 80:327-333.

Warkentin, I. G., and P. C. James. 1988. Trends in winter distribution and abundance of ferruginous hawks. J. Field Ornithol. 59:209-214.

Welty, J. C. 1962. The Life of Birds. Philadelphia: W. B. Saunders Company. 546pp.

Westoby, M., and F. H. Wagner. 1973. Use of a crested wheatgrass seeding by black-tailed jackrabbits. J. Range Manage. 26:349-352.

Weston, J. B. 1968. Nesting ecology of the ferruginous hawk (*Buteo regalis*). M.S. thesis. Brigham Young Univ., Provo, Ut. 40pp.

Weston, J. B. 1969. Nesting ecology of the ferruginous hawk *Buteo regalis*. Brigham Young Univ. Sci. Bull., Biol. Ser. 10:25-36.

White, C. M., and T. L. Thurow. 1979. Ferruginous hawk and geothermal development. Unpubl. Rep. Brigham Young University, Provo, Utah. Submitted to the U.S. Dep. Energy and EG&G Idaho, Inc., Idaho Falls. 22pp.

White, C. M., and T. L. Thurow. 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. Condor 87:14-22.

Wiens, J. A., and M. I. Dyer. 1975. Rangeland avifaunas: their composition, energetics, and role in the ecosystem. Pages 146-182 *in* D. R. Smith, ed. Symposium on management of forest and range habitats for nongame birds. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. WO-1, Washington, D.C.

Williams, R. D., and E. W. Colson. 1989. Raptor associations with linear rights-of-way. Pages 173-192 *in* Proc. western raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Wittenhagen, K. W. 1991. 1991 progress report on the ferruginous hawk in southeastern Montana. Unpubl. Rep. U.S. Bur. Land Manage., Miles City, Mont. 24pp.

Wittenhagen, K. W. 1992. 1992 final report on the ferruginous hawk in southeastern Montana. Unpubl. Rep. U.S. Bur. Land Manage., Miles City, Mont. 31pp.

Woffinden, N. D. 1975. Ecology of the ferruginous hawk (*Buteo regalis*) in central Utah: population dynamics and nest site selection. M.S. thesis. Brigham Young Univ., Provo, Ut. 102pp.

Woffinden, N. D., and J. R. Murphy. 1977a. Population dynamics of the ferruginous hawk during a prey decline. Great Basin Nat. 37:411-425.

Woffinden, N. D., and J. R. Murphy. 1977b. Roadside raptor census in the eastern Great Basin, 1973-1974. Raptor Res. 11:62-66.

Woffinden, N. D., and J. R. Murphy. 1983a. Ferruginous hawk nest site selection. J. Wildl. Manage. 47:216-219.

Woffinden, N. D., and J. R. Murphy. 1983b. Ferruginous hawk postfledging activities. North Am. Bird Bander 8:94-96.

Woffinden, N. D., and J. R. Murphy. 1989. Decline of a ferruginous hawk population: a 20-year summary. J. Wildl. Manage. 53:1127-1132.

Yensen, D. 1982. A grazing history of southwestern Idaho with emphasis on the Birds of Prey study area. U.S. Dep. Inter., Bur. Land Manage., Boise, Id. 82pp.

Yoakum, J., W. P. Dasmann, H. R. Sanderson, C. M. Nixon, and H. S. Crawford. 1980. Habitat improvement techniques. Pages 329-409 *in* S. D. Schemnitz, ed. Wildlife Management Techniques Manual, Fourth Edition. The Wildl. Soc, Washington, D.C. 686pp.

Young, L. S. 1989. Effects of agriculture on raptors in the western United States: an overview. Pages 209-218 *in* Proc. western raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Appendix A. Km^2 per laying pair, clutch size, and productivity for ferruginous hawk studies done through 1992.

State or Province	Study Yr. (# Laying Pairs)	Km^2 per Pair	Clutch Size (Eggs/Pair)	Productivity (Young/Pair)
Colorado	Olendorff (1975)			
	1972 (26)	99.6	--	1.8
	Anderson and Craig (1975)			
	1973 (36)	--	--	1.5
	Anderson and Craig (1977)			
	1975 (38)	--	--	2.8
	Craig and Anderson (1979)			
	1977 Comanche (15)	—	--	3.1
	1977 Pawnee (29)	--	--	1.6
	Leslie (1992)			
	1990 (16)	--	--	0.9
	Stalmaster (1988)			
	1981 (9)	--	--	3.1
	1982 (23)	--	--	2.6
	1983 (27)	--	--	2.6
	1984 (30)	--	--	1.4
	1985 (15)	--	--	1.1
	1986 (11)	--	--	0.8
	1987 (16)	--	--	1.5
	1988 (17)	--	--	2.2
	Andersen & Rongstad (1989)			
	1983 (3)	347.3	--	1.7
	1984 (9)	115.8	--	0.9
	1985 (14)	75.9	--	1.8
	1986 (13)	80.2	--	0.8
	1987 (13)	80.2	--	2.1
	1988 (11)	94.7	--	1.4
Idaho	Howard (1975)			
	1972 (38)	73.6	2.9	2.2
	1973 (27)	103.6	2.8	2.0
	Powers and Craig (1976)			
	1972 (11)	306.1	--	0.8
	Thurow et al. (1980)			
	1972 (17)	58.1	--	3.0
	1973 (15)	65.9	--	2.5
	1974 (13)	76.0	--	2.5
	1975 (13)	76.0	--	2.4
	1976 (11)	89.8	--	2.5
	1977 (8)	123.5	--	2.9
	1978 (17)	58.1	--	3.5
	1979 (21)	47.0	--	3.6
	1980 (24)	41.2	--	2.6
	Janes (1985)			
	1982 (13)	21.0	--	--

Appendix A. Continued.

State or Province	Study Yr. (# Laying Pairs)	Km^2 per Pair	Clutch Size (Eggs/Pair)	Productivity (Young/Pair)
Kansas	Roth and Marzluff (1989)			
	1979 (59)	536.5	3.4	2.9
	1980 (36)	879.2	3.0	2.3
	1981 (42)	753.6	2.8	2.2
	1982 (41)	772.0	2.9	2.1
	1983 (41)	772.0	2.8	2.0
	1984 (39)	811.6	2.4	1.8
	1985 (36)	879.2	2.6	2.1
	1986 (43)	736.1	2.8	2.1
	1987 (39)	811.6	3.1	1.9
Montana	Meyers (1987)			
	1985 (69)	15.7	--	1.8
	1986 (58)	18.6	--	1.4
	Harmata (1991)			
	1990 (23)	22.5	--	--
	Wittenhagen (1991, 1992)			
	1991 (21)	44.6	3.0	1.4
	1992 (22)	42.6	3.3	2.1
	Black (1992)			
	1992 (8)	81.9	--	--
Nevada	Perkins (1982)			
	1981 (27)	--	--	2.8
	1982 (65)	--	--	2.6
	Herron (1989)			
	1989 (31)	--	--	--
	1990 (27)	--	--	--
	1991 (34)	--	--	--
New Mexico	J. M. Ramakka, Bur. Land Management, and R. T. Woyewodzic, Bur. Indian Affairs (pers. commun.)			
	1981 (4)	--	--	1.5
	1982 (4)	--	--	2.5
	1983 (3)	--	--	1.7
	1984 (7)	--	--	2.1
	1985 (7)	--	--	1.4
	1986 (12)	--	--	1.3
	1987 (26)	--	--	1.9
	1988 (26)	--	--	2.0
North Dakota	Gilmer and Wiehe (1977)			
	1976 (21 on towers)	--	--	--
	1976 (24 not/towers)	--	--	--
	Gilmer and Stewart (1983)			
	1977 (78)	16.1	4.1	2.2

Appendix A. Continued.

State or Province	Study Yr. (# Laying Pairs)	Km^2 per Pair	Clutch Size (Eggs/Pair)	Productivity (Young/Pair)
	1978 (64)	19.7	(comb.)	(comb.)
	1979 (97)	13.0	(comb.)	(comb.)
	Gaines (1985)			
	1983 (75)	16.8	--	1.5
	1984 (79)	15.9	--	1.6
Oregon	Lardy (1980)			
	1979 (32)	9.8	3.9	3.2
	Cottrell (1981)			
	1979 (21)	17.3	--	1.9
	1980 (26)	13.0	--	1.4
	Janes (1985)			
	1978 (1-Antelope)	137.0	--	--
	1981 (7-Boardman)	26.4	--	--
	1981 (13-Heppner)	34.5	--	--
	Henjum (1987)			
	1986 (33)	--	--	--
South Dakota	Lokemoen and Duebbert (1976)			
	1973 (15)	17.9	4.4	2.1
	1974 (12)	22.4	(comb.)	(comb.)
	Blair (1978)			
	1976 (18)	389.0	3.3	2.1
	1977 (17)	412.0	(comb.)	(comb.)
Utah	Weston (1968)			
	1967 (13)	64.8	1.5	0.6
	1968 (14)	60.1	3.6	2.0
	Smith and Murphy (1973)			
	1967 (6)	34.5	2.5	1.1
	1968 (9)	23.0	3.7	2.1
	1969 (12)	17.2	3.7	2.7
	1970 (7)	29.6	3.0	1.4
	Smith and Murphy (1978)			
	1967 (15)	78.0	2.5	0.9
	1968 (28)	42.0	3.7	2.0
	1969 (34)	34.5	3.8	2.6
	1970 (12)	97.5	2.9	0.8
	Janes (1985)			
	1982 (17)	16.1	--	--
	Woffinden and Murphy (1989)			
	1967 (13)	18.3	--	0.6
	1968 (14)	17.0	--	2.0

Appendix A. Continued.

State or Province	Study Yr. (# Laying Pairs)	Km^2 per Pair	Clutch Size (Eggs/Pair)	Productivity (Young/Pair)
	1969 (12)	19.1	--	2.8
	1970 (7)	34.0	--	1.4
	1971 (5)	47.6	--	3.0
	1972 (15)	15.9	--	2.1
	1973 (7)	34.0	--	1.0
	1974 (3)	76.7	--	1.0
	1977 (4)	57.5	--	2.5
	1978 (1)	238.0	--	--
	1980 (4)	57.5	--	2.8
	1981 (1)	238.0	--	--
	1982 (2)	119.0	--	--
	1983 (1)	238.0	--	3.0
	1984 (0)	--	--	0.0
	1985 (2)	119.0	--	--
	1986 (0)	--	--	0.0
Washington	Beery (1974)			
	1974 (9)	4,261.0	--	0.6
	Fitzner et al. (1977)			
	1975 (12)	3,237.3	--	2.5
	L. D. Jurs, Bur. Land Management (pers. commun.)			
	1975 (6)	--	--	--
	1978 (5)	--	--	--
	1979 (8)	--	--	--
	1980 (6)	--	--	--
	1981 (5)	--	--	--
	1984 (7)	--	--	--
	1985 (6)	--	--	--
	1987 (12)	--	--	1.8
	1988 (5)	--	--	1.6
	1989 (6)	--	--	1.8
	1990 (3)	--	--	1.0
	1991 (6)	--	--	--
Wyoming	Wadell and Yde (1979)			
	1979 (8)	46.0	--	--
	1979 (5)	123.2	--	--
	Platt (1986)			
	1979 (9)	28.2	--	3.0
	1980 (5)	50.8	--	1.4
	1981 (6)	42.3	--	1.3
	1982 (8)	31.2	--	1.6
	1983 (15)	16.9	--	1.9

Appendix A. Continued.

State or Province	Study Yr. (# Laying Pairs)	Km^2 per Pair	Clutch Size (Eggs/Pair)	Productivity (Young/Pair)
	1984 (15)	16.9	--	0.5
	1985 (12)	21.2	--	2.1
	MacLaren (1986)			
	1981 (17)	41.9	--	2.5
	1982 (13)	55.0	--	2.5
	Call and Tigner (1991)			
	1987 (31) (NN)	--	--	1.2
	1988 (8) (NN)	--	--	1.3
	1988 (11) (ANS)	--	--	3.5
	1989 (16) (NN)	--	--	1.6
	1989 (34) (ANS)	--	--	1.9
	1990 (6) (NN)	--	--	2.2
	1990 (33) (ANS)	--	--	2.5
	1991 (4) (NN)	--	--	1.5
	1991 (41) (ANS)	--	--	2.3
Alberta	Schmutz (1977)			
	1975 (26)	13.0	--	--
	1976 (24)	20.0	--	--
	Schmutz (1984)[1]			
	1982 (1,082)	69.0	--	--
	Schmutz (1987)[1]			
	1987 (1,791)	41.8	--	--
	Schmutz (1993)[1]			
	1992 (1,702)	45.8	--	--
Saskatchewan	Houston (1991)			
	1971 (6)	10.6	--	3.0
	1972 (5)	12.7	--	3.2
	1973 (6)	10.6	--	2.0
	1974 (9)	7.1	--	3.7
	1975 (5)	12.7	--	4.0
	1976 (6)	10.6	--	3.4
	1977 (9)	7.1	--	3.3
	1978 (7)	9.1	--	3.3
	1979 (7)	9.1	--	4.0
	1980 (7)	9.1	--	2.1
	1981 (7)	9.1	--	3.0
	1982 (7)	9.1	--	3.3
	1983 (7)	9.1	--	3.2
	1984 (7)	9.1	--	3.3
	1985 (8)	7.9	--	3.4
	1986 (9)	7.1	--	2.9
	1987 (9)	7.1	--	3.3
	1988 (9)	7.1	--	3.1

Appendix A. Continued.

State or Province	Study Yr. (# Laying Pairs)	Km^2 per Pair	Clutch Size (Eggs/Pair)	Productivity (Young/Pair)
	Banasch (1990)[1]			
	1988 (21)	107.0	--	--

[1] = studies based on a sampling procedure; only a small number of the nests actually found.

NN = natural nest; ANS = artificial nest site.

comb. = years combined.

Appendix B. Ferruginous hawk prey from 20 studies.*

COMMON NAME	SCIENTIFIC NAME	SUB-TOTALS	N	WEIGHT** (G.)	TOTAL BIOMASS	% OCCUR.	% BIO-MASS
Mammals (Subtotals)		5166				(83.28)	(95.32)
Bats	*Myotis (sp.)*	1	1	10	10	0.02	0.00
Lagomorphs--Hares and Rabbits (Subtotals)		1228				(19.80)	(65.89)
White-tailed jackrabbit	*Lepus townsendii*		226	3,360	759,360	3.64	23.13
Black-tailed jackrabbit	*L. californicus (aver.)*		634	1,536	973,824	10.22	29.66
Unidentified jackrabbits***			74	2,129	157,546	1.19	4.80
Desert cottontail	*Sylvilagus audubonii*		197	941	185,377	3.18	5.65
Eastern cottontail	*S. floridanus*		14	1,135	15,890	0.23	0.48
Nuttall's cottontail	*S. nuttallii*		13	650	8,450	0.21	0.26
Pygmy rabbit	*S. idahoensis*		4	340	1,360	0.06	0.04
Unidentified cottontails (aver.)			65	927	60,255	1.05	1.84
Unidentified rabbits***			1	1,115	1,115	0.02	0.03
Badger (Subtotals)		3				(0.05)	(0.26)
Badger	*Taxidea taxus (neonate)*		3	2,833	8,499	0.05	0.26
Rodents--Marmots (Subtotals)		1				(0.02)	(0.06)
Yellow-bellied marmot	*Marmota flaviventris (aver.)*		1	1,808	1,808	0.02	0.06
Rodents--Squirrels and Prairie Dogs (Subtotals)		2719				(43.83)	(25.35)
Washington ground squirrel***	*Spermophilus washingtoni*		16	150	2,400	0.26	0.07
Thirteen-lined ground squirrel	*S. tridecemlineatus*		496	198	98,208	8.00	2.99
Spotted ground squirrel***	*S. spilosoma*		2	113	226	0.03	0.01
Rock squirrel***	*S. variegatus*		5	150	750	0.08	0.02
Townsend's ground squirrel	*S. townsendii (aver.)*		102	177	18,054	1.64	0.55
Richardson's ground squirrel	*S. richardsonii*		1506	280	421,680	24.28	12.85
Belding's ground squirrel***	*S. beldingi*		44	120	5,280	0.71	0.16
White-tailed antelope squirrel	*Ammospermophilus leucurus*		79	105	8,295	1.27	0.25
Unidentified ground squirrels			179	181	32,399	2.89	0.99
Black-tailed prairie dog***	*Cynomys ludovicianus*		22	400	8,800	0.35	0.27
White-tailed prairie dog	*C.gunnisoni*		260	907	235,820	4.19	7.18
Least chipmunk	*Tamias minimus (aver.)*		8	32	256	0.13	0.01
Rodents--Pocket Gophers (Subtotals)		492				(7.93)	(2.62)
Northern pocket gopher	*Thomomys talpoides*		416	170	70,720	6.71	2.15
Townsend's pocket gopher	*T. townsendii (aver.)*		76	200	15,200	1.23	0.46
Rodents--Pocket Mice (Subtotals)		47				(0.76)	(0.02)
Great Basin pocket mouse	*Perognathus parvus*		26	17	442	0.42	0.01
Hispid pocket mouse***	*P. hispidus*		21	15	315	0.34	0.01
Rodents--Kangaroo Rats (Subtotals)		412				(6.64)	(0.67)
Ord's kangaroo rat	*Dipodomys ordii*		381	53	20,193	6.14	0.62
Chisel-toothed kangaroo rat***	*D. microps*		18	56	1,008	0.29	0.03
Unidentified kangaroo rats***			13	55	715	0.21	0.02

COMMON NAME	SCIENTIFIC NAME	SUB-TOTALS	N	WEIGHT** (G.)	TOTAL BIOMASS	% OCCUR.	% BIO-MASS
Rodents--Cricetine Mice and Rats (Subtotals)		135				(2.18)	(0.09)
Western harvest mouse	*Reithrodontomys megalotis*		8	11	88	0.13	0.00
Deer mouse	*Peromyscus maniculatus*		76	19	1,444	1.23	0.04
Northern grasshopper mouse	*Onychomys leucogaster*		3	26	78	0.05	0.00
Unidentified mice			37	17	629	0.60	0.02
Desert woodrat	*Neotoma lepida*		6	124	744	0.10	0.02
Bushy-tailed woodrat	*N.cinerea (aver.)*		3	277	831	0.05	0.03
Unidentified wood rat (aver.)			2	281	562	0.03	0.02
Rodents--Microtine Mice and Rats (Subtotals)		83				(1.34)	(0.11)
Meadow vole	*Microtus pennsylvanicus*		8	23	184	0.13	0.01
Montane vole	*M. montanus (aver.)*		13	35	455	0.21	0.01
Prairie vole	*M. ochrogaster*		1	23	23	0.02	0.00
Sagebrush vole	*Lemmiscus curtatus (aver.)*		23	30	690	0.37	0.02
Unidentified voles***			37	33	1,221	0.60	0.04
Muskrat	*Ondatra zibethicus*		1	922	922	0.02	0.03
Rodents--Old World Mice (Subtotals)		8				(0.13)	0.00
House mouse	*Mus musculus (aver.)*		7	19	133	0.11	0.00
Western jumping mouse***	*Zapus princeps*		1	25	25	0.02	0.00
Unidentified Rodents		3	3	50	150	0.05	0.00
Rodents (Subtotals)		3899				(62.86)	(28.86)
Carnivores--Mustelids (Subtotals)		12				(0.19)	(0.05)
Long-tailed weasel***	*Mustela frenata*		10	180	1,800	0.16	0.05
Ermine***	*M. erminea*		2	40	80	0.03	0.00
Unidentified Mammals (Subtotals)		22				(0.35)	(0.20)
Unidentified mammals***			22	295	6,490	0.35	0.20
Birds (Subtotals)		822				(13.25)	(4.14)
Anseriformes							
Mallard	*Anas platyrhynchos*		5	1,185	5,925	0.08	0.18
Northern pintail	*A. acuta*		1	976	976	0.02	0.03
Blue-winged teal	*A. discors*		3	395	1,185	0.05	0.04
Unidentified ducks (aver.)			27	767	20,709	0.44	0.63
Galliformes							
Gray partridge	*Perdix perdix*		6	389	2,334	0.10	0.07
Ring-necked pheasant	*Phasianus colchicus*		6	1,138	6,828	0.10	0.21
Sage grouse	*Centrocercus urophasianus*		26	1,581	41,106	0.42	1.25
Unidentified Galliformes (aver.)			1	727	727	0.02	0.02
Falconiformes							
American kestrel	*Falco sparverius*		3	114	342	0.05	0.01
Ferruginous hawk (nestling)***	*Buteo regalis*		1	300	300	0.02	0.01
Charadriiformes							
Long-billed curlew	*Numenius americanus*		5	587	2,935	0.08	0.09

COMMON NAME	SCIENTIFIC NAME	SUB-TOTALS	N	WEIGHT** (G.)	TOTAL BIOMASS	% OCCUR.	% BIO-MASS
Wilson's phalarope***	*Steganopus tricolor*		1	70	70	0.02	0.00
Unidentified Charadriiformes***			1	104	104		
Columbiformes							
Mourning dove	*Zenaida macroura (aver.)*		12	134	1,608	0.19	0.05
Strigiformes							
Burrowing owl	*Speotyto cunicularia (aver.)*		1	170	170	0.02	0.01
Short-eared owl	*Asio flammeus*		2	348	696	0.03	0.02
Piciformes							
Northern flicker	*Colaptes auratus*		4	142	568	0.06	0.02
Passeriformes (Subtotals)		644				(10.38)	(1.34)
Say's phoebe	*Sayornis saya*		3	23	69	0.05	0.00
Horned lark	*Eremophila alpestris*		110	26	2,860	1.77	0.09
Green-tailed towhee***	*Oberholseria chlorura*		1	41	41	0.02	0.00
Pinyon jay	*Gymnorhinus cyanocephalus*		1	108	108	0.02	0.00
Black-billed magpie	*Pica pica*		40	170	6,800	0.64	0.21
Rock wren	*Salpinctes obsoletus*		3	17	51	0.05	0.00
Mountain bluebird	*Sialia currucoides*		2	35	70	0.03	0.00
Sage thrasher	*Oreoscoptes montanus*		2	37	74	0.03	0.00
Sprague's pipit	*Anthus spragueii*		3	25	75	0.05	0.00
European starling	*Sturnus vulgaris*		1	79	79	0.02	0.00
Sage sparrow	*Amphispiza belli*		3	18	54	0.05	0.00
Brewer's sparrow	*Spizella breweri*		2	11	22	0.03	0.00
Vesper sparrow	*Pooecetes gramineus*		3	27	81	0.05	0.00
Lark bunting	*Calamospiza melanocorys*		14	38	532	0.23	0.02
Chestnut-collared longspur	*Calcarius ornatus*		1	19	19	0.02	0.00
Western meadowlark	*Sturnella neglecta*		308	95	29,260	4.97	0.89
Unidentified passerines			147	25	3,675	2.37	0.11
Unidentified birds		73	73	76	5,548	1.18	0.17
Amphibians							
Woodhouse's toad***	*Bufo woodhousei*		1	20	20	0.02	0.00
Northern leopard frog***	*Rana pipiens*		1	38	38	0.02	0.00
Unidentified toad***			1	20	20	0.02	0.00
Reptiles							
Leopard lizard	*Gambelia wislizenii*		5	26	130	0.08	0.00
Desert horned lizard	*Phrynosoma platyrhinos*		15	24	360	0.24	0.01
Short-horned lizard***	*P. douglassii*		1	18	18	0.02	0.00
Western fence lizard	*Sceloporus occidentalis*		1	18	18	0.02	0.00
Western whiptail	*Cnemidophorus tigris*		13	17	221	0.21	0.01
Unidentified lizard			9	17	153	0.15	0.00
Western hognose snake***	*Heterodon nasicus*		12	25	300	0.19	0.01
Racer	*Coluber constrictor*		22	77	1,694	0.35	0.05
Striped whipsnake	*Masticophis taeniatus*		6	111	666	0.10	0.02
Gopher snake	*Pituophis catenifer*		44	226	9,944	0.71	0.30

COMMON NAME	SCIENTIFIC NAME	SUB-TOTALS	N	WEIGHT** (G.)	TOTAL BIOMASS	% OCCUR.	% BIO-MASS
Western rattlesnake	*Crotalus viridis*		1	425	425	0.02	0.01
Unidentified snake			3	190	570	0.05	0.02
Unidentified reptiles			12	111	1,332	0.19	0.04
Amphibians and Reptiles (Subtotals)		147				(2.37)	(0.48)
Insects (Subtotals)		68				(1.10)	0.00
Coleoptera							
Scarabaeidae--Scarab beetles***			28	1	28	0.45	0.00
Unidentified insects***			40	1	40	0.64	0.00
Grand Totals		**N/A**	**6203**	**N/A**	**3,282,782**	**100.00**	**100.00**

* References to the 20 studies used are shown in Table 4. Number of prey items per study is shown in Table 5.

** Body weights of prey item derived from Lokemoen and Duebbert (1976), Thurow et al. (1980), Diller and Johnson (1982), Steenhof (1983), MacLaren (1986), Stalmaster (1988), and Dunning (1993).

*** Estimated body weight.

Appendix C: Other Ferruginous Hawk Literature.

Adams, R. J., Jr. 1978. A ferruginous hawk in Michigan. Jack-Pine Warbler 56:51-52.

Allen, H. 1985. Status of the ferruginous hawk (*Buteo regalis*) nesting sites in Washington. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Andersen, D.E. 1988. Behavioral aspects of raptor-human interactions and telemetry experiments in southeastern Colorado. Ph.D Diss. Univ. Wisconsin, Madison. 124pp.

Andersen, D. E., O. J. Rongstad, and W. R. Mytton. 1988. Home range changes in breeding raptors exposed to increased human activity levels in southeastern Colorado. Page 316 *in* Proc. southwest raptor management symposium and workshop. Natl. Wildl. Fed., Washington, D.C.

Angell, T. 1969. Study of the ferruginous hawk: adult and brood behavior. Living Bird 8:225-241.

Anonymous. 1973. Recoveries and foreign retraps--ferruginous hawk. Western Bird Bander 48:48.

Backus, P. 1986. Hawks soar into BLM highlight. Newspaper article. Tribune Examiner dated July 1, 1986. Dillon, Mont.

Base, D. L., and G. A. Siever. 1987. Experimental use of artificial nesting structures for grassland raptors in the Oklahoma Panhandle. Eyas 10:30-31.

Bechard, M. J., and K. D. Hague. 1985. Nesting distribution of the ferruginous hawk in southern Idaho. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Bechard, M. J., and C. S. Houston. 1984. North Dakota oologists. Blue Jay 42:176-183.

Biggs, A. 1965. Are the roughlegs (*B. regalis*) returning? Can. Audubon 27:78-79.

Black Butte Coal Company. 1981. Proposal to accommodate energy development and raptor populations on and adjacent to the Black Butte Coal Company Mine Permit Area, Sweetwater County, Wyoming. Unpubl. Rep. Black Butte Coal Company, Point of Rocks, Wyo. 37pp.

Blair, C. L. 1976. Nesting ecology and food selection of the ferruginous hawk in northwestern South Dakota. Quart. Rep. South Dakota Coop. Wildl. Res. Unit, Brookings. 13:5.

Blair, C. L. 1982. Ferruginous hawk using rock in nest defense. Raptor Res. 15:120.

Bock, C. E., and L. W. Lepthien. 1976. Geographical ecology of the common species of Buteo and Parabuteo wintering in North America. Condor 78:554-557.

Bolduc, A. 1988. Ferruginous hawk in Grant County. Loon 60:52.

Bowles, J. H., and F. R. Decker. 1931. Ferruginous rough-leg in Washington. Murrelet 12:65-70.

Bridges, J. M. 1980. Raptor nesting platforms and the need for further studies. Pages 113-116 *in* R. P. Howard and J. F. Gore, eds. Proceedings of a workshop on raptors in energy developments. Idaho Chap., The Wildl. Soc., Boise, Id.

Bry, E. 1976. Ferruginous hawk. North Dakota Outdoors 39(2):1.

Bulger, J. B., L. Salzer, and S.G. Herman. No Date. Raptors of the Grass Creek Resource Area, Bighorn Basin, Wyoming. U.S. Bur. Land Manage. Contract No. YA-512-CT9 120. Prepared by Biosystems Analysis, Inc., Santa Cruz, Calif. 58pp.

Call, M. W. 1978. Nesting habitats and surveying techniques for common western raptors. U.S. Bur. Land Manage. Tech. Note T/N-316. 115pp.

Call, M. W. 1980. Nesting habitats and general status of the ferruginous hawk. Unpubl. Rep. U.S. Bur. Land Manage. Denver, Colo. 6pp.

Clark, W. S. 1981. Flight identification of common North American buteos. Continental Bird Life 2:139-143.

Cooper, J. E., and S. L. Pugsley. 1984. Mesothelioma in a ferruginous hawk (*Buteo regalis*). Avian Pathol. 13:797-801.

Coues, E. 1877. Eastward range of the ferruginous buzzard (*Archibuteo ferrugineus*). Bull. Nuttall Ornithol. Club 2:26.

Decker, F. R., and J. H. Bowles. 1926. Status of the ferruginous roughleg in the State of Washington. Murrelet 7:54.

Dille, F. M. 1885. Ferruginous rough-leg. Oologist 2:44-45.

DuMont, P. A. 1934. Observations of the ferruginous rough-leg in Iowa. Wilson Bull. 46:262.

Froggatt, K. 1986. Preliminary survey of ferruginous hawks and other raptors in the Consort-Sedalia area of Wildlife Management Unit 164 (June 17-19, 1986). Unpubl. Rep. Forestry, Lands and Wildl., Fish and Wildl. Div., Wildl. Branch, Central Region, Alta.

Fyfe, R. W. 1976. Status of Canadian raptor populations. Can. Field-Nat. 90:370-375.

Gaines, R. C. 1985. Nest site selection, nesting success, and fledging success of the ferruginous hawk (*Buteo regalis*) in central North Dakota: a comparison of two studies. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Gilbertson, B. 1982. Minnkota Power Coop and the hawks. Hawk Chalk 21:51-54.

Glinski, R. L. 1985. Status of the ferruginous hawk in Arizona. Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Goelitz, W. A. 1918. Destruction of nests by farming operations in Saskatchewan. Auk 35:238-240.

Grantmyer, K. 1992. Ferruginous hawk (*Buteo regalis*) in the Rockies. Alberta Nat. 22:14.

Green, G. A., and M. L. Morrison. 1983. Nest-site characteristics of sympatric ferruginous and Swainson's hawks. Murrelet 64:20-22.

Gustafson, D. K. 1971. Ferruginous hawk at Bong Recreation Area. Passenger Pigeon 33:195.

Hall, R. S. 1985 Preliminary status report and notes on the breeding biology of the ferruginous hawk (*Buteo regalis*) in northwestern Arizona. Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Henny, C. J. 1985. Review of organochlorine pesticide residues in ferruginous hawk eggs. Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Herron, G. B. 1985. Status of the ferruginous hawk (*Buteo regalis*) in Nevada. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Hodson, K. 1968. Porcupine in ferruginous hawk's nest. Blue Jay 26:180-181.

Houston, C. S. 1984. Unusual story--record 20-year longevity of ferruginous hawk. Blue Jay 42:99-101.

Houston, C. S., and M. J. Bechard. 1985. Decline of the ferruginous hawk in Saskatchewan. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Howard, R. P. 1977. Breeding ecology of the ferruginous hawk in northern Utah and southern Idaho. Abstract only. Raptor Res. 11:78.

Howard, R. P. 1980. Artificial nest structures and grassland raptors. Pages 117-123 *in* R. P. Howard and J. F. Gore, eds. Proceedings of a workshop on raptors and energy developments. Idaho Chap., The Wildl. Soc., Boise, Id.

Howard, R. P., L. O. Wilson, and F. B. Renn. 1976. Relative abundance of nesting raptors in southern Idaho. Raptor Res. 10:120-128.

Jacot, E. C. 1934. Arizona nest of the ferruginous roughleg. Condor 36:84-85.

Jewett, S. 1926. Ferruginous roughleg nesting in Oregon. Condor 28:245-246.

Jonkel, G. M. 1966. Ferruginous hawks nesting near Holabird. South Dakota Bird Notes 18:14-15.

Jurs, L. D. 1986. Supplement to the Juniper Forest Habitat Management Plan. Unpubl. Rep. U.S. Bur. Land Manage., Spokane, Washington, and Washington Dep. Game, Olympia. 7pp.

King, D., D. Hastings, and M. Hastings. 1988. Communal winter roosts of ferruginous hawks in San Diego County, California. West. Birds 19:170-171.

Kocan, A. A., J. Snelling, and E. C. Greiner. 1977. Some infections and parasitic diseases in Oklahoma raptors. J. Wildl. Dis. 13:304-306.

Kochert, M. N., K. Steenhof, and J. Doremus. 1985. Ferruginous hawk nesting surveys in the Snake River Birds of Prey Area: implications for long-term monitoring. Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif. 20pp.

Lardy, M. E. 1986. Raptor inventory and ferruginous hawk breeding biology in southeastern Oregon. Abstract only. Raptor Res. 20:46.

Lloyd, H. 1937. Twenty-year-old ferruginous roughlegged hawk. Can. Field-Nat. 51:137.

Lockhart, J. M., and G. R. Craig. 1985. Distribution and status of nesting ferruginous hawks in Colorado. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

MacLaren, P. A. 1987. Resource partitioning in an assemblage of breeding raptors from southwestern Wyoming. Abstract only. J. Raptor Res. 21:46.

McKenna, M. G., and R. W. Seabloom. 1976. Ferruginous hawk. Page 41 *in* Threatened and unique wildlife of North Dakota: initial status report. Inst. Ecol. Studies Res. Rep. No. 13. Univ. North Dakota, Grand Forks.

McLaren, P. L., and M. A. McLaren. 1973. Sight record of the ferruginous hawk in British Columbia. Blue Jay 31:59.

Millard, S. 1980. Immature ferruginous hawk. Loon 52:90-91.

Nelson, B. B. 1985. Ferruginous hawk (*Buteo regalis*) distribution and nest site characteristics in south central Wyoming. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

North Dakota Outdoors. 1976. Ferruginous hawk. 39:Inside front cover.

Olendorff, R. R. 1971. Morphological aspects of growth in three species of buteos. Ph.D. Diss. Colorado State Univ., Fort Collins. 460pp.

Olendorff, R. R. 1972. Large birds of prey of the Pawnee National Grassland: nesting habits and productivity 1969-1971. U.S. Int. Biol. Prog., Grassland Biome, Fort Collins, Colo. Tech Rep. 151. 59pp.

Olendorff, R. R. 1972. Comments on rearing young raptors. Raptor Res. 6:6-10.

Olendorff, R. R. 1974. Some quantitative aspects of growth in three species of buteos. Condor 76:466-468.

Olendorff, R. R., and A, M. Fish. 1985. Biology of the ferruginous hawk: a review. Unpubl. Rep. U.S. Bur. Land Manage. Sacramento, Calif. 100pp.

Olendorff, R. R., and M. N. Kochert. 1977. Land management for the conservation of birds of prey. Pages 294-307 *in* R. D. Chancellor, ed. World Conf. on Birds of Prey, Rep. on Proceedings. Int. Counc. Bird Preserv. Vienna, Austria.

Pearson, D. 1966. Adult ferruginous hawk. Loon 38:75.

Perkins, M. W. 1982. Tree-nesting raptors in Nevada. North Am. Bird Bander 7:105-106.

Platt, J. B. 1971. Survey of nesting hawks, eagles, falcons, and owls in Curlew Valley, Utah. Great Basin Nat. 31:51-65.

Porter, R. D. 1951. Status of rough-legged hawks in Idaho. Condor 53:257-258.

Porter, R. D., and C. M. White. 1977. Status of some rare and lesser known hawks in Western United States. Pages 39-57 *in* R. D. Chancellor, ed. World Conf. on Birds of Prey, Rep. of Proc. Int. Counc. Bird Preservation. Vienna, Austria.

Ratcliffe, B. D. 1987. Ferruginous hawk report for Manitoba. Page 205 *in* G. L. Holroyd, W. B. McGillivray, P. H. R. Stepney, D. M. Ealey, G. C. Trottier, and K. E. Eberhart, eds. Proc. workshop on endangered species in the prairie provinces. Prov. Mus. Alta. Nat. Hist. Occas. Pap. No. 9.

Rolfe, E. S. 1898. Notes from the Devil's Lake Region. Osprey 10:125-128.

Roth, S. 1980. Monitoring raptor populations in northwestern Kansas: third year of a continuing census, June, 1980. Unpubl. Rep. Kansas Fish and Game Comm., Pratt. 18pp.

Roth, S. 1981. Monitoring raptor populations in northwestern Kansas: fourth year of a continuing census, June, 1981. Unpubl. Rep. Kansas Fish and Game Comm., Pratt. 2pp.

Roth, S. D., Jr., and J. M. Marzluff. 1985. Status of ferruginous hawks in western Kansas. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Russell, R. P. 1965. Ferruginous hawk sight record for Morrison County (Minnesota). Loon 37:109.

Schmidt, R. 1981. Ferruginous hawk breeding documented in Sargent County, North Dakota. Prairie Nat. 13:32.

Schwilling, M. 1983. Hawk of the high plains. Kansas Wildl. 40:10-16.

Sherrod, S. K. 1978. Diets of North American falconiformes. Raptor Res. 12:49-52, 69-70, 77-78.

Skeen, J. E., G. A. Sievert, and D. L. Base. 1987. Grassland raptor nesting platforms in the Oklahoma Panhandle. Paper presented at the Oklahoma Ornithol. Soc. Fall 1987 meeting. Murray State College, Tashoningo, Okla. 6pp.

Smith, D. G. 1971. Population dynamics, habitat selection, and partitioning of breeding raptors in the eastern Great Basin of Utah. Ph.D. Diss. Brigham Young Univ. Provo, Ut. 271pp.

Schmutz, J. K. 1985. Distribution, reproduction, and survival of ferruginous hawks in Alberta. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Simbeck, D. J. 1989. Ferruginous Hawk (*Buteo regalis*) recorded in Colbert County (Alabama). Alabama Birdlife 36:3.

Snyder, R. L., and C. D. Cheney. 1974. Alternation in two hawk species. Proc. Utah Acad. Sci. Arts and Letters 51:84-85.

Snyder, R. L., W. Jenson, and C. D. Cheney. 1976. Environmental familiarity and activity: aspects of prey selection for a ferruginous hawk. Condor 78:138-139.

Stabler, R. B., and P. A. Holt. 1965. Hematozoa from Colorado birds. II. Falconiformes and Strigiformes. J. Parasit. 51:927-928.

Stahlecker, D. W., and H. J. Griese. 1979. Raptor use of nest boxes and platforms on transmission towers. Wildl. Soc. Bull. 7:59-62.

Stalmaster, M. V., and J. M. Lockhart. 1985. Nesting ecology of the ferruginous hawk on a western Colorado/eastern Utah study area. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Stalmaster, M. V., W. Wright, J. M. Lockhart, and R. Kruger. 1982. Management of nesting ferruginous hawks in relation to coal development in Colorado and Utah. Thorne Ecol. Inst. Tech. Publ. 14:205-209.

Stone, C. P., and R. D. Porter. 1979. Use of cable in ferruginous hawk (*Buteo regalis*) nest. Raptor Res. 13:47-48.

Struzik, E. 1991. Grassland stalker. Equinox 9:58-67.

Thompson, S. P. 1985. Status of the ferruginous hawks (*Buteo Regalis*) in southeast Oregon. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Thompson, T. D. 1990. 1990 Juniper Forest Management Area raptor survey. Unpubl. Rep. U.S. Bur. Land Manage. Spokane, Wash. 4pp.

U.S. Fish and Wildlife Service. 1977. Habitat requirements as they relate to ferruginous hawks' (*Buteo regalis*) tolerance to humans and other animals. Unpubl. Rep. Boise, Id. 7pp.

U.S. Fish and Wildlife Service. 1982. Endangered and threatened wildlife and plants; review of vertebrate wildlife for listing as endangered or threatened species. Federal Register 47(251):58453-58460, December 30, 1982.

Wakeley, J. S. 1974. Activity periods, hunting methods, and efficiency of the ferruginous hawk. Raptor Res. 8:67-72.

Wakeley, J. S. 1978a. Activity budgets, energy expenditures, and energy intakes of nesting ferruginous hawks. Auk 95:667-676.

Wakeley, J. S. 1979. Use of hunting methods by ferruginous hawks in relation to vegetation density. Raptor Res. 13:116-119.

Ward, B. 1968. Wyoming's ground nesting hawks. Wyo. Wildl. 32:15-17.

Warner, D. W. 1948. Ferruginous rough-leg (*Buteo regalis*) in Minnesota in July. Loon 20:83.

Wasserburger, T., J. Hanna, and C. Patterson. 1985. Raptor nesting inventory, 1985, Washakie Resource Area. Unpubl. Rep. Wyo. Coop. Fishery and Wildl. Res. Unit. Laramie, Wyo. Prepared for the U.S. Bur. Land Manage. 18pp.

Weigand, J. P. 1967. Ferruginous hawk attacks great horned owl. Auk 84:433.

Weston, J. B., and D. H. Ellis. 1968. Ground nesting of the ferruginous hawk in westcentral Utah. Great Basin Nat. 28:111.

White, C. M., T. (L.) Thurow, and J. F. Sullivan. 1979. Effects of controlled disturbance on ferruginous hawks as may occur during geothermal energy development. Pages 777-780 *in* Expanding the geothermal frontier, transactions. Vol. 3. Geothermal Resour. Counc., Davis, Calif.

Williams, R. B., and C. P. Matteson, Jr. 1948. Wyoming hawks. Wyoming Game and Fish Dep., Cheyenne. Bull. No. 5. 84pp.

Woffinden, N. D., and J. R. Murphy. 1982. Analysis of nesting materials from a Great Basin ferruginous hawk nest. Raptor Res. 16:1-4.

Woffinden, N. D., and J. R. Murphy. 1985. Status of a breeding population of the ferruginous hawk in central Utah: an 18-year summary. (Abstract only.) Paper presented at the 1985 Raptor Res. Found. Annu. Meeting, Sacramento, Calif.

Wyman, L. E. 1914. Ferruginous rough-leg at Los Angeles. Condor 16:145.

Wyman, L. E. 1926. Banded ferruginous rough-leg. Condor 28:98.

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